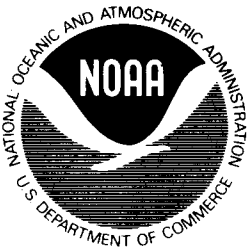# NOAA Technical Memorandum NMFS-SEFC- 162

A COMPARISON OF FORAGE FISH COMMUNITIES IN RELATION TO HABITAT PARAMETERS IN FAKA UNION BAY, FLORIDA AND EIGHT COLLATERAL BAYS DURING THE WET SEASON

David R. Colby, Gordon W. Thayer,
William F. Hettler, and David S. Peters

NOAA Technical Memorandum NMFS-SEFC-162

A COMPARISON OF FORAGE FISH COMMUNITIES IN RELATION TO HABITAT PARAMETERS IN FAKA UNION BAY, FLORIDA AND EIGHT COLLATERAL BAYS DURING THE WET SEASON

David R. Colby, Gordon W. Thayer, William F. Hettler, and David S. Peters

November, 1985

A COMPARISON OF FORAGE FISH COMMUNITIES IN RELATION TO HABITAT PARAMETERS IN FAKA UNION BAY, FLORIDA AND EIGHT COLLATERAL BAYS DURING THE WET SEASON

David R. Colby, Gordon W. Thayer, William F. Hettler, and David S. Peters

November 1985

National Marine Fisheries Service, NOAA
Southeast Fisheries Center
Beaufort Laboratory
Beaufort, North Carolina   28516

ABSTRACT

Forage fish communities were sampled in the estuarine bay system of the Ten Thousand Islands region of Florida in order to develop a basis for predicting changes in the fish communities in Faka Union Bay following future modification of freshwater inflow to that bay. A comparative approach was employed to relate fish community characteristics (species composition, relative abundance, size, and food consumed) to habitat characteristics (salinity, sediments, and aquatic vegetation). Surveys were conducted in July, August, and September 1982 and in February, May, June, and August 1983. During each survey, 16 stations were randomly selected in Faka Union Bay (Stratum I) and also in the bays to the east (Stratum II) and the west (Stratum III). Samples were collected at each station with otter and surface trawls and analyzed for fish and macroinvertebrtae species composition, relative abundance, and size. Bottom cores and plant and shell material taken from each trawl were used to describe general habitat types. Additionally, fish stomach contents were analyzed to determine differences among areas as well as possible salinity-related differences in food consumed by the communities.

During the rainy season, salinity was reduced more rapidly and to a greater extent in Faka Union Bay than in the system of bays to the east and west because of freshwater input from Faka Union Canal.

Numbers and biomass of fish per station and numbers of certain macroinvertebrates were substantially lower in Faka Union Bay than in the other bays within the system, but Faka Union Bay does not support a taxonomically different or unique forage fish community. Habitat availability does not explain lower densities of fishes in Faka Union Bay because comparisons of average relative fish densities within 12 different

habitat types revealed that, in 11 of the 12 comparisons, relative fish densities were less in those habitats within Faka Union Bay than in those same habitats elsewhere. Food availability does not appear to be a limiting factor, but variation in abundance of a particular food type (e.g., polychaetes) may nevertheless affect the relative abundance of fishes preferring that food type. The majority of fishes were collected over a wide range of salinities. Ordination of occurrence and relative abundance of fishes with respect to salinity showed salinity "optima" that, for the dominant species collected, generally were at intermediate to high salinities rather than at low salinities. The ordination analyses should be useful for predicting which forage fishes will become more prevalent in Faka Union Bay during the rainy season, should water management policies and programs restructure inflow patterns so that salinities in Faka Union Bay approach those of bays to the east and west. However, a direct effect of salinity cannot be considered the only factor contributing to reduced numerical abundance of fish in Faka Union Bay, because during May 1983, salinities within all strata were high and similar, yet the relative abundance of fishes in Faka Union Bay was less than half that of the adjacent bays.

INTRODUCTION

The wetland areas of Florida are critical to the valuable commercial and recreational fisheries of the State because between 66-90% of the harvested species depend on coastal marshes or estuaries for at least part of their life cycle. Estuarine ecosystems provide pre-recruits with abundant food resources, a relative scarcity of predators, and low competition with adults. The upland and wetland areas of coastal Florida, however, have undergone extensive development in the past 20 years. For example, the pattern of freshwater inflow into Faka Union Bay in the Ten Thousand Island area of Florida was greatly altered by channelization of the upland drainage basin in the vicinity of Golden Gate Estates in the 1960's (Department of the Army 1980). This channelization has resulted in a point source discharge of freshwater into Faka Union Bay rather than overland flow that normally occurs; salinity patterns generally are lower in this bay during the rainy season (late May-September) than elsewhere in the Ten Thousand Island area as a result of this discharge (Carter et al. 1973).

Modification of freshwater inflow has been recognized as a major threat to the integrity of estuaries in the United States (Cross and Williams 1981). Usually the problem is that of reduced freshwater inflow as a result of consumptive use of water for agriculture, industry, and municipal water supply. In Faka Union Bay however, channelization and artificial enlargement of the upland drainage basin has actually increased the total amount and amplitude of freshwater inflow to that bay, while lowering the water table and reducing aquifer recharge on the upland basin.

Following the construction of Faka Union Canal, several scientific studies were carried out to sample fishery populations and habitats in Faka

Union Bay or adjacent bays (e.g., Carter et al. 1973, Lindall et al. 1974, Yokel 1975, Collins and Finucane 1984). These studies, in many instances, reported reduced or altered fish and invertebrate species compositions relative to an adjacent area. The EPA report (Carter et al. 1973) is the most complete study of the general area, although the fishery study was only a portion of the total study, and only compared Faka Union Bay and Fakahatchee Bay. Carter et al. (1973) strongly suggest that man-induced alterations of the Faka Union Bay estuary have caused changes in fishery communities: "A greater abundance and diversity of fishes inhabited Fahkahatchee Bay, an essentially undisturbed estuary, than Fahka Union Bay, a man-influenced environment." (p. II-4).

Objectives and Rationale

The overall objective of the current investigation was to assess the nursery value of the Faka Union Bay and adjacent bay systems in the Ten Thousand Islands and how it changes with freshwater inflow or salinity. To place the potential impacts associated with excessive freshwater inflow into Faka Union Bay into perspective, we selected a strategy of intensive short-term comparative studies that were designed to relate fish community characteristics (species composition, abundance, average size, and food consumed) to habitat characteristics (water depth, salinity, bottom type, and macroinvertebrate abundance) in Faka Union Bay as well as in the rest of the bay systems between Goodland and Chokoloskee.

AREA AND METHODS

Sampling Area

The Ten Thousand Islands area is a large, shallow complex of bays, passes, and islands located on the Gulf coast in southwestern Florida (Fig. 1). It is bordered on the east by the town of Chokoloskee and on the west by the town of Goodland. It measures approximately 26 km east to west and 5 km north to south. The area is surrounded by mangrove swamps and dominated by islands primarily supporting growth of red mangrove, Rhizophora mangle (Davis 1946).

Numerous rivers drain into the bay complex along its entire length, and each bay communicates, though sometimes via a circuitous route, with the Gulf of Mexico. As previously noted, the pattern of freshwater flow into Faka Union Bay was greatly altered by channelization of the upland drainage basin in the 1960's. This channelization resulted in a point source discharge into Faka Union Bay rather than overland flow into many different bays as normally occurs. Detailed descriptions of the area, including its climatology and hydrology, are provided by Carter et al. (1973).

After an initial reconnaissance trip in June 1982, large sampling areas were delineated which encompassed each of the major bays and passes between Chokoloskee and Goodland. This sampling area did not include the much more confined waters amidst the mangrove islands along the southern boundaries of the bay/pass complex because of numerous snags, oyster bars, and lack of adequate sampling space to complete a set of tows with the gears.

Water depth, bottom type, and ease of sampling varied throughout the sampling area. Bays to the east of Faka Union Bay were somewhat deeper, and more easily sampled than those to the west. This was possibly due to the
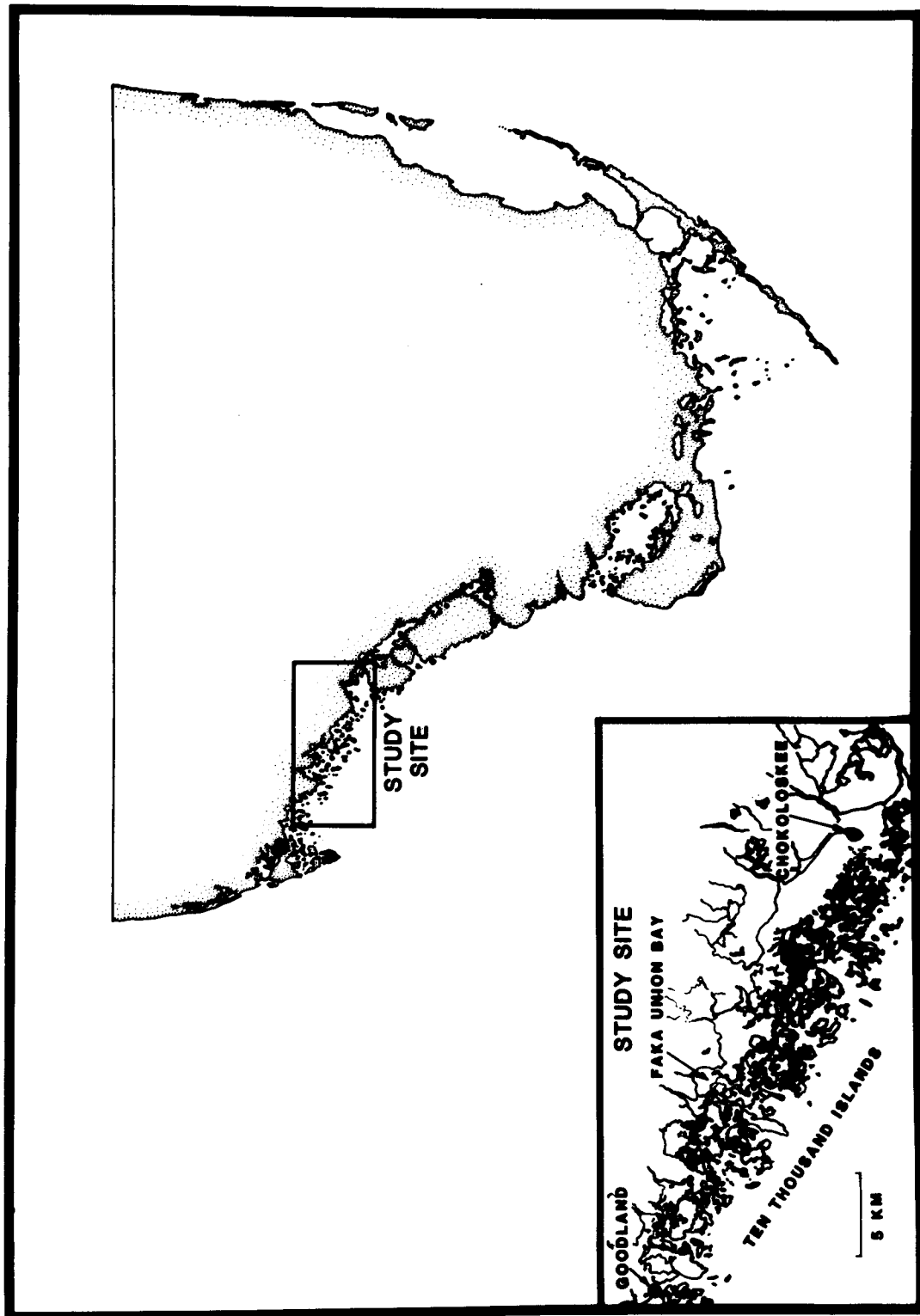
Figure 1. Diagram of south Florida with an inset showing the general location of the sampling area.

bottom being better "swept" by tidal currents in the eastern portion of the system than in the more enclosed western bays.

Bottom type varied throughout the system. Oyster reefs, hard sand, shell, mud, and almost fluid mud areas could be found at various sites. Water depth varied from 0.3 to 1.5 m (MLW) in the bays. The channels between bays and those communicating with the Gulf were as deep as 4 to 6 m.

Sampling sites were chosen with the aid of two sets of aerial photographs that were obtained from the Photogrammetry Branch of the National Ocean Survey, Rockville, Maryland. The boundaries of the entire sampling area - as determined from the reconnaissance trip - were delineated on the first set, which consisted of black and white photographs at a scale of 1:21,000. Infra-red photographs at a scale of 1:11,000 were useful for the positioning of these boundaries. A transparent grid of points was superimposed over the black and white photographs, and points falling within the selected survey area were numbered sequentially and listed.

On each of seven survey trips, 48 stations were sampled. Each station was selected using a computer program designed to draw 48 random numbers corresponding to numbered potential stations. Restrictions placed on the selection of locations were: (1) 16 stations were selected from the 87 available in Faka Union Bay (Stratum I), (2) 16 were selected from the 1,336 available in the area between Faka Union Bay and the town of Chokoloskee (Stratum II), and (3) 16 were selected from the 442 available between Faka Union Bay and the town of Goodland (Stratum III). Three additional alternative stations within each area were also selected in case the primary sampling sites could not be reached.

A different set of 48 stations was selected for each survey. The stations were pinpointed and noted on photographic reproductions (1:75,000

scale), and these photographs were carried into the field. Figure 2 provides

a composite of sample locations visited during the study. The boundaries of

the sampling area extended from the western side of Goodland Bay to the point

where Highway 29 crosses Chokoloskee Bay to the town of Chokoloskee. To the

north, the boundary was designated by the shoreline and at river mouths. The

south boundary was designated as a line drawn along the perceived southern

extent of each bay adjacent to the island-pass complex leading to the Gulf of

Mexico.

Sampling Protocol

Given the spatial separation of the 48 sample sites, a sampling

scheme was followed so that, optimally, 10 sites were visited on each of the

first 4 days of the sampling trip and the remaining 8 sites were visited on

the fifth day. This scheme was flexible, however, in order to take into

account delays due to weather, breakdowns, etc. Hence, on some days, as few

as four or as many as 12 stations may have been sampled.

To avoid intensive sampling in a single bay or small area that might

miss possible inter-bay or inter-area differences, sample sites were chosen to

allow visits to stations in Faka Union Bay and other bays during a single day.

Additionally, tidal fluctuations were taken into account so as to allow site

sampling in Faka Union and other bays to occur at ebb, flood, and slack water

on differing days.

Seven sampling trips were carried out during the project. The

trip dates were: July 21-25, August 25-30, September 23-27, 1982; and

February 16-21, May 18-22, June 15-19, and August 17-22, 1983. At each

station, surface and bottom trawls were taken in a northerly direction. Each

trawl was pulled for a period of 2 min at a (clean net, hard bottom, no
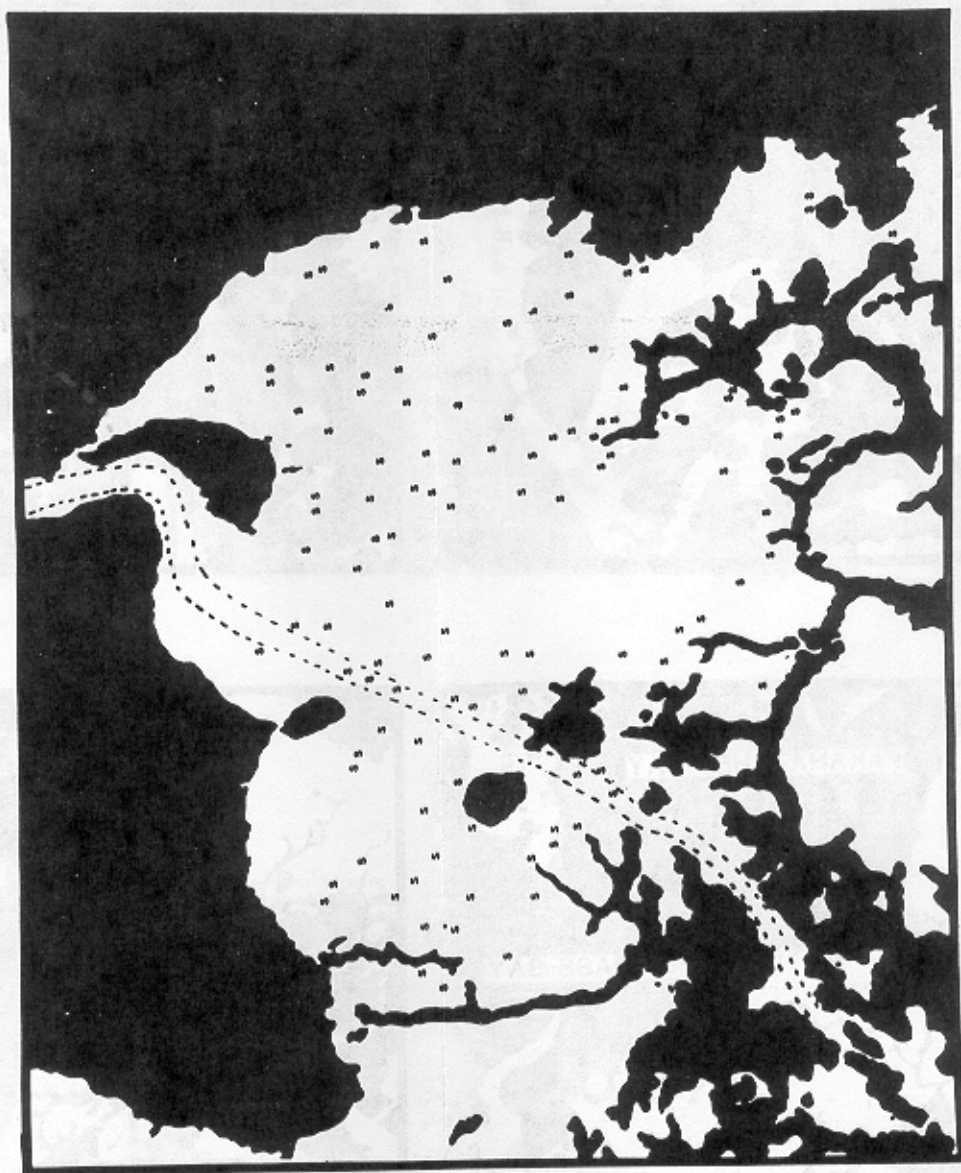
Figure 2.   Location of sites sampled within Faka Union Bay.

PALM BAY

BUTTONWOODS BAY

SUGAR BAY

FAKAHATCHEE BAY

WEST PASS BAY

LANE COVE

PUMPKIN BAY

FAKA UNION BAY

(See Blowup)

CHOKOLOSKEE BAY
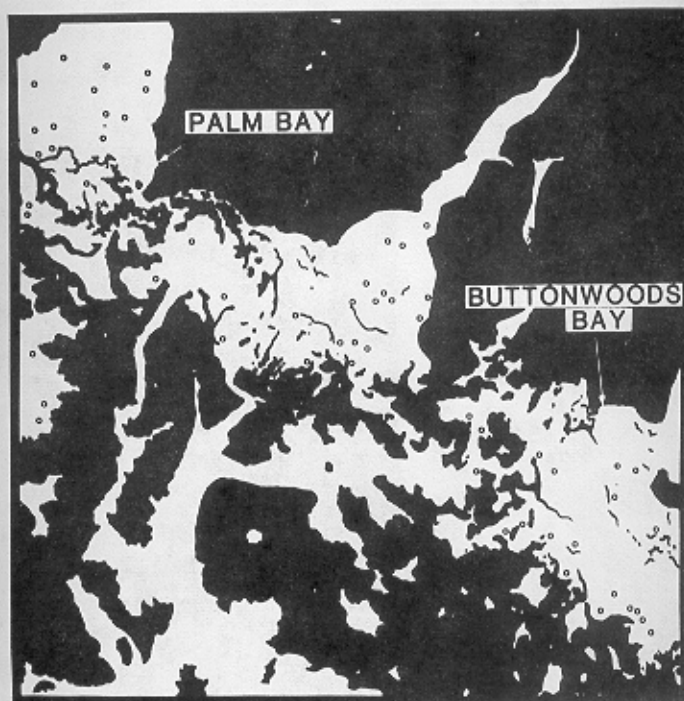
FIGURE 2
Diagrams showing the location of stations sampled during seven
surveys in the Faka Union Bay area of the Ten Thousand Islands.
Open circles indicate station locations. There were only 87
available sites in Faka Union Bay and 112 stations were visited
over the study. Several of the sites were sampled more than once
(never on the same survey) while others were missed entirely
because of the random selection process.
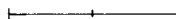
snags, etc.) speed of 3.0-3.5 knots. This speed was verified on three separate occasions by towing the nets over a fixed distance and recording the time taken to cover that distance.

The surface trawl used was a modification of the net described by Massman et al. (1952). It measures 6.6 m at the head rope, 6.2 m at the foot rope, and is 0.7 m deep. Wing mesh is 6-mm (1/4") bar with a 3-mm (1/8") mesh tail bag. The trawl was towed between two boats which deployed the net over the stern while maintaining slight headway. When the tow lines came taut, the boats separated -- thus opening the net --and a 2-min. trawl was begun. At the end of the haul, the boats were brought together, the catch removed from the net and then bagged, labeled, and preserved in a 10% formalin solution.

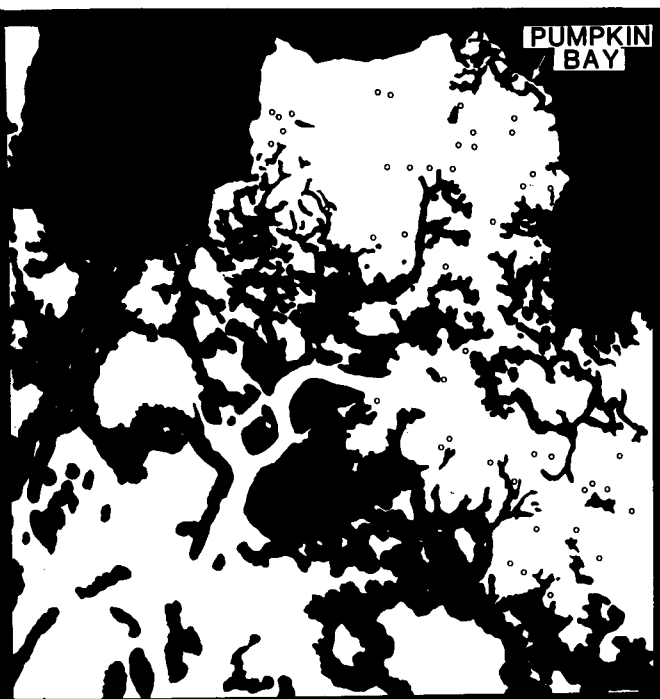The otter trawl used was made from the same netting material, 6-mm (1/4") bar with a 3-mm (1/8") mesh tail bag. The net measured 3.4-m at the head rope and 3.8-m at the foot rope. It also was fitted with a 7.3-m length of 3-mm (1/8") chain, strung between the trawl boards, to serve as a tickler chain. The trawl was deployed by paying the net over the side of the boat while making slight headway in a circular direction. The trawl boards were not deployed until the boat was on station and headed in a northerly direction. Upon release of the boards, the boat moved ahead until the tow ropes were taut and the timed haul then began and terminated after 2 min.

Larger fish can avoid these gear, but the nets provide reliable estimates of relative abundance of late stage larval and juvenile fish. This is not to say that there was no net avoidance, but we assume it to be consistent among the samples. Additionally, both gears proved successful in collecting these organisms from all habitat types encountered: bare substrates, algal and seagrass beds, and shell bottoms.

Sampling trawls were not routinely replicated on station. However, for comparison, replicate tows were made at several stations in February 1983. These did, in fact, provide similar catches. For example, a surface trawl at one station provided 217 anchovy, 522 menhaden, and 3 silver perch, while a replicate tow at the same station provided 289 anchovy, 631 menhaden, and 3 silver perch.

The only major sampling problem encountered in the use of either gear occurred when the otter trawl fished through a large algal bed. The tickler chain tended to kick the algae up into the path of the oncoming net and caused it to become fouled after a short time. If, after several attempts, the bed proved too dense, an alternate site (previously designated) was utilized. This was necessary only twice during the course of the project, despite the fact that about 40% of the trawl samples were taken over algae beds. Circling nets or small drop nets would probably be effective for sampling very dense algae beds.

After each use of the otter trawl, all fish and invertebrates were sorted from the catch, bagged, labeled, and preserved in a 10% formalin solution. In addition, qualitative observations were recorded to indicate the major bottom type (i.e., seagrass, algae, detritus, or shell) over which the otter trawl was taken, as indicated by the presence of such materials in the tail bag.

Additionally, at each station, midway along and directly adjacent to each trawl line, surface and bottom temperature, salinity (all by Beckman[1] electrodeless induction salinometer), current speed (calibrated TSK current meter) and current direction measurements were taken. Light penetration (Secchi disc) and water depth to the nearest cm were taken, and a sample of the top 5 cm of sediment was taken using a 4-cm diameter corer.

---

[1] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

At the end of each sampling trip, all samples were brought to the Beaufort Laboratory and analyzed. Fish from each trawl were identified to species, counted, and each species wet weighed as a measure of biomass. A record was kept of the number of individuals and weight of each species by gear. Invertebrates also were sorted from these collections.

Analysis of stomach contents of the fish from the combined collections of the otter trawl and surface trawls at each station and date was conducted to provide 48 community samples for each collection period. Juvenile fish, 10 cm or less in total length, were subsampled from the preserved trawl catches of fish from 144 station-samples collected in 1982 and from 61 station-samples collected in 1983. Only catches made before 1000 h were included in 1983 samples because analysis of the 1982 samples indicated that the majority of species were morning and evening feeders and that fish collected before 1000 had a higher proportion of recognizable food in their gut than fishes collected after this time. A Motoda splitter (Motoda 1959), which halved a sample each time it was operated, was used to subsample to less than 40 specimens per station. The bay anchovy was the most numerous species in most samples and was split to less than 20 fish in each subsample. Anchovy collected from the same station contained redundant stomach contents, therefore their numbers were reduced to save processing time. Anchovy stomach contents were analyzed separately, but the data were grouped with the entire station fish community for station-by-station analysis. Stomachs of all fish in each subsample were removed, opened, and the contents were separated microscopically into 11 primary food categories; within these categories, 36 secondary food types were visually estimated as a percentage of the primary category. This process resulted in up to 36 food

types for each sample, but most station groups contained less than 15 food types. The 36 categories included:

alga	gastropod, terrestrial
amphipod	invertebrate, egg
bivalve, larva	insect
bivalve, whole	isopod
bivalve, siphon	mite
chitin	nematode
chironomid, larva	ostracod
copepod	polychaete
crab, whole or parts	seagrass
crustacean, nauplius	sea hare
crustacean, megalops	shrimp, adult
crustacean, zoea	sipunculid
detritus	squid
diatom	tanaid
dipteran, larva	tipulid
echinoderm, larva	trematode
fish and fish scales	tunicate, larva
gastropod, larva	unidentified animal remains

Each primary food category sample was oven dried at 70°C for 18 h and weighed to the nearest 0.01 mg. Sand grains and similar inorganic residues were not weighed. The percent by weight that each secondary food type contributed to the subsample's diet was calculated, as was the percent fullness. Stomach content wet weight in milligrams was divided by fish wet weight in grams as an estimate of percent fullness for comparisons of feeding success among strata.

Invertebrates collected by both otter and surface trawls were sorted and transferred to alcohol. Larger organisms were identified and counted. Amphipods and isopods were not always identified to genus and species, but were always counted to provide a measure of their collective abundance. Keys used included Miner (1950), Williams (1965, 1974), Menzies and Frankenberg (1966), Schultz (1969), Gosner (1971), Boesfield (1973), Felder (1973), and Bynum and Fox (1977).

A total of 288 sediment cores were taken during this study; no sediment cores were taken in February 1983. Sediment cores were dried at 65°C, pulverized, and weighed subsamples were taken for organic content analysis (loss of weight upon ignition at 500°C for 24 h). The remaining dry sediment was weighed and wetted using a saturated sodium hexametaphosphate solution, and wet seived. Material retained on 4.00 mm (shell) and 0.063 mm (sand) sieves was redried and the difference between the initial total dry weight and the sum of these two size fractions was taken as a measure of silt-clay content. This procedure is a modification from the American Society for Testing and Materials (1963).

RESULTS AND DISCUSSION

Precipitation: Monthly rainfall records over a 30-yr period at Everglades City, Florida, show a 6-month period between November and April of generally low precipitation, ranging from 1.43 inches (in) for November to 2.19-in during April. Intermediate precipitation levels of about 4-in occur during October and May. During the rainy season, which extends from June through September, large discharges of freshwater pass through the Faka Union Canal (Carter et al. 1973). Over the 30-yr period, precipitation averaged 8.65-in per month during the rainy season with a narrow range of 7.34-in in August to 9.60-in during June (Fig. 3).

Rainfall during 1982-1983 followed a pattern similar to the 30-yr average with lower rainfall in fall through spring and higher precipitation during summer. However, during June-August 1982, normal rainfall was exceeded by 15-in at Everglades City with an extreme of 17.72-in during June compared to a 30-yr norm of 9.60-in (Fig. 3). September through December had

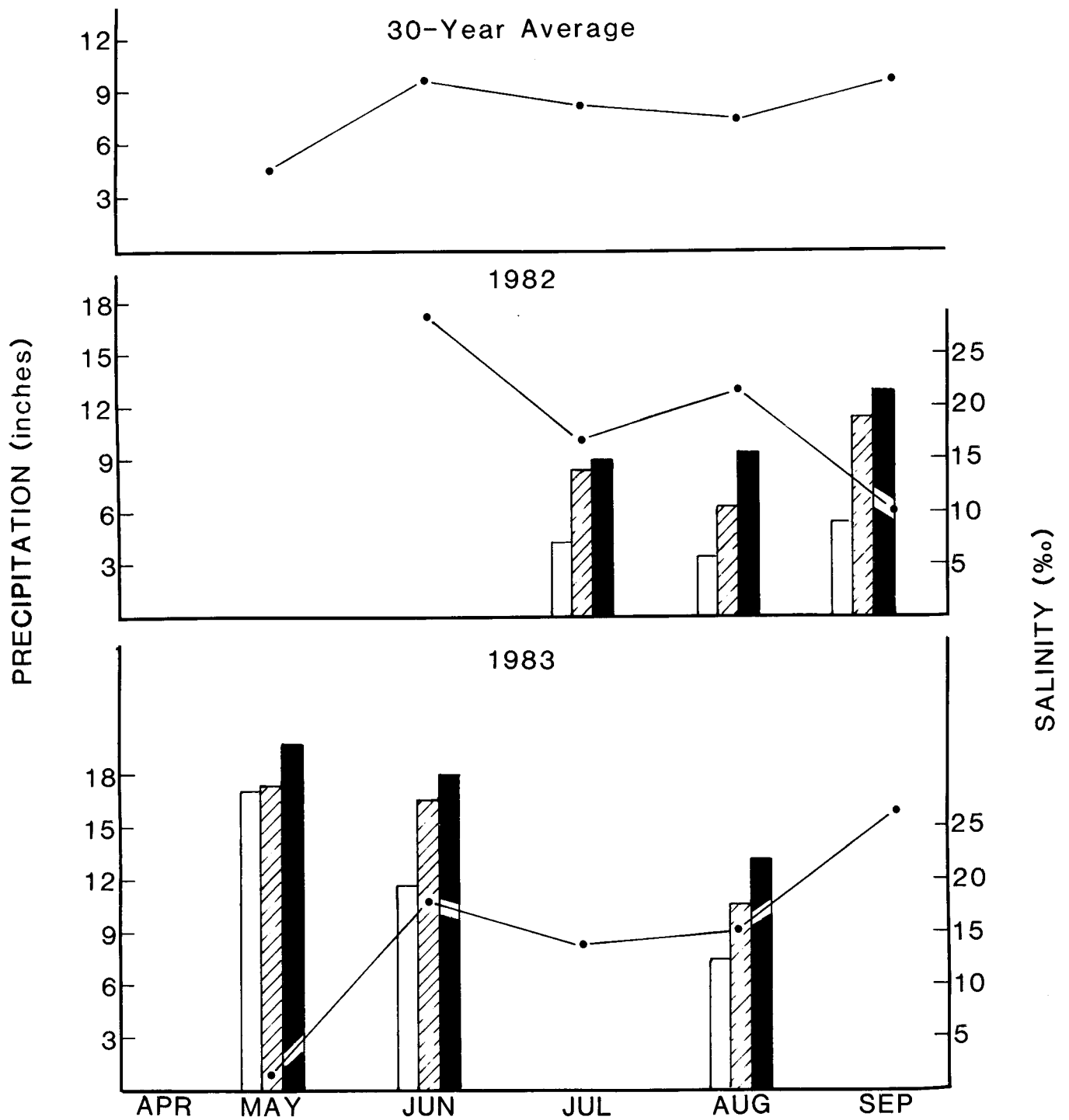Note: page number "14" at the top.

Figure 3. Monthly rainfall (inches) over a 30-year average and during the 1982 and 1983 wet season survey periods (solid line). Also shown are mean stratum salinities (Stratum I = clear vertical bar; Stratum II = hatched bar; Stratum III = solid bar). Values are averaged surface and bottom salinities.

either normal or below normal rainfall, but during January-March 1983 rainfall exceeded the normal by 9.84-in, and during April and May rain fell below the 30-yr average by 4.8-in. During summer 1983, precipitation exceeded normal levels by almost 3-in (Fig. 3).

Salinity: Average salinity for our sampling area and differences in salinity among the three strata reflected differences in both precipitation between years and differences in freshwater discharge to the areas. Average salinities (surface and bottom mean) for the entire sampling area were 11 ^{o}/oo lower during the 1982 wet season survey than during the 1983 wet season (Fig. 3), but we hasten to point out that because surveys were conducted at different times in 1982 than in 1983, comparisons among years are of less interest and validity than comparisons among strata. The average salinity for the 48 stations (a surface and bottom measurement at each) sampled in Faka Union Bay was 7.3 ^{o}/oo in 1982 while it averaged 20 ^{o}/oo over the 3-month sample period during summer 1983. These stratum-means were approximately 7 ^{o}/oo and 5 ^{o}/oo lower than the means for bays to the east during both 1982 and 1983, respectively; they were about 10 ^{o}/oo and 8 ^{o}/oo lower than the bay complex to the west of Faka Union Bay during 1982 and 1983, respectively. During the unusually rainy winter of 1983, Faka Union Bay also displayed a lower average salinity (11 ^{o}/oo) compared to bays to the east (19 ^{o}/oo) and west (23 ^{o}/oo).

The average salinity of Faka Union Bay changed more slowly due to reduced rainfall and both more rapidly and to a greater degree due to the onset of the rainy season than occurred in bays to the east or west. It is obvious that the excessive precipitation in June 1982 (8-in over normal) had depressed bay-wide salinity levels in Faka Union Bay by July. Further

precipitation in July and August resulted in a measured decrease average bay-wide salinity of only 1 $^o/oo$ (from 7 $^o/oo$ in July to 6 $^o/oo$ in August). During this same period, the bay system to the east (Stratum II) displayed a decrease from an average of 14 $^o/oo$ in July to 11 $^o/oo$ in August, while to the west (Stratum III) bay-wide salinities actually increased slightly (Fig. 3). With decreasing precipitation from August to September 1982, mean salinities increased only to 9 $^o/oo$ from an August mean of 6 $^o/oo$ in Faka Union Bay. There was a larger overall increase in salinity to 19 $^o/oo$ in Stratum II and to 21.5 $^o/oo$ for Stratum III. Thus, the response of Faka Union Bay to reduced rainfall was slower than for either of the bay systems to the east or west. During the 1983 sampling period, increased precipitation between May and June resulted in a 8 $^o/oo$ decrease in the average salinity of Faka Union Bay. There was little change in mean salinity in the bay system to the east and only a 3 $^o/oo$ decrease in Stratum III to the west. Thus, the response of Faka Union Bay to the onset of the rainy season between May and June was more rapid than in the other two strata.

These comparisons of salinities between strata (Fig. 4) lead us to agree with Carter et al. (1973) that the Faka Union Canal discharge reduces salinity in that bay below the region's normal salinity. Lower salinities occurred at stations nearer the seaward boundary of Faka Union Bay than occurred within either of the other strata. It was not unusual to observe lower salinities at the juncture between Faka Union and Fakahatchee Bays than in the mid-bay portion of Fakahatchee Bay. This suggests a flow toward the east out of Faka Union Bay.
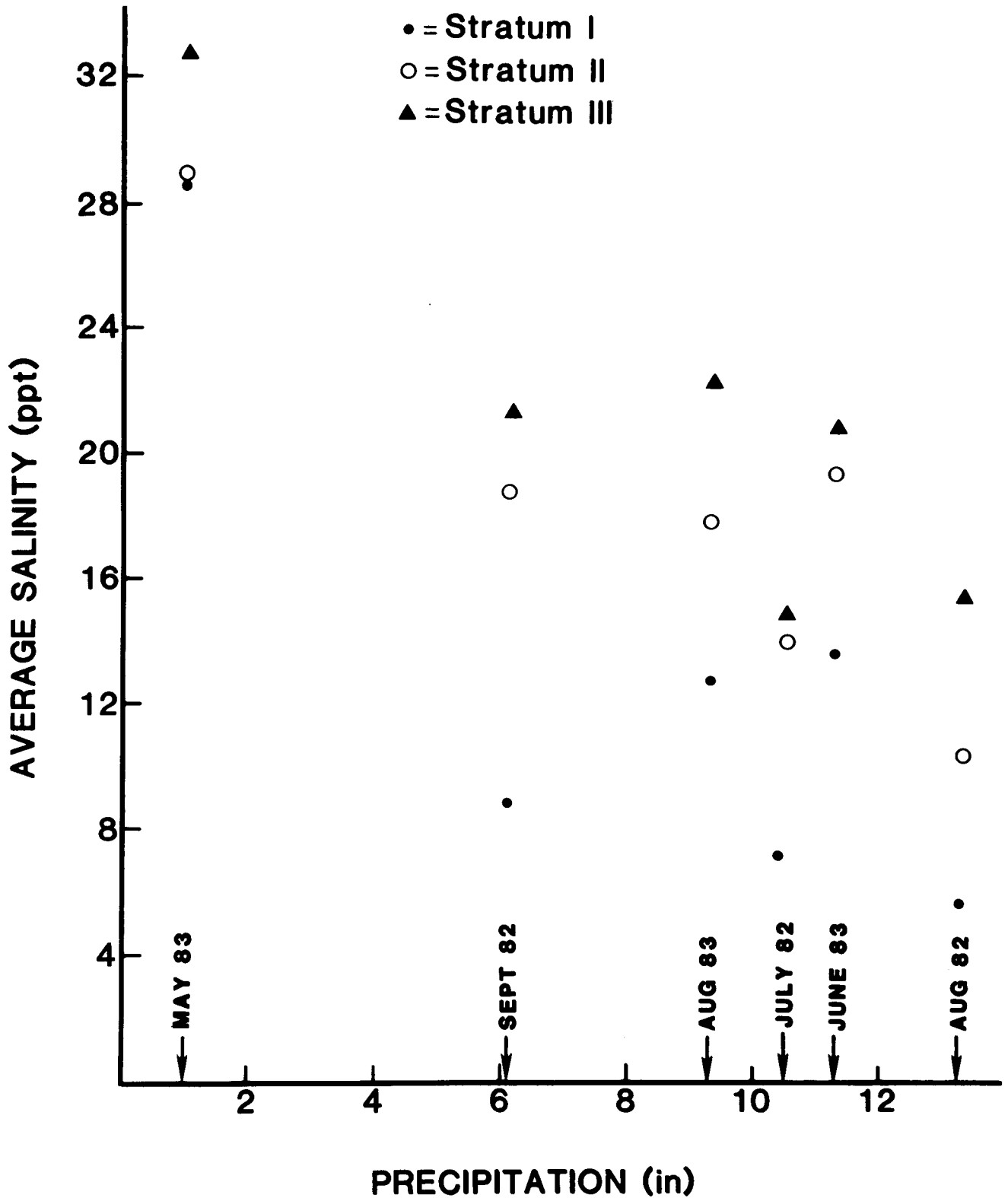
Figure 4. Relationship between average salinity and total monthly precipitation
for each of the surveys conducted during the wet seasons of 1982 and
1983. Stratum I = Faka Union Bay, Stratum II = bays to the east
of Faka Union Bay, Stratum III = bays to the west of Faka Union Bay.

Sediments: In order to identify general bottom characteristics for the
sample areas, bottom cores (top 5 cm of sediment) were taken and analyzed for
silt-clay and organic matter content at all stations. Ninety-six cores were
taken within each stratum during the six wet season surveys. Samples taken
in close proximity but in different survey periods showed no obvious evidence
of temporal variability. Therefore, each data point was plotted separately
on charts of the area (Figs. 5 and 6). Areas having similar silt-clay or
organic matter values were contoured, and their areas estimated (Tables 1 and
2). The contour boundaries are only approximations and, hence, serve only to
show general trends in the distribution of the sediments.

There were considerable differences in sediment characteristics
among the three sample strata, although they can all be considered as
generally well sorted, fine grained sands and silt-clay, which is a sediment
generally considered mud to sandy-mud. Sediments in the area to the east were
quite uniform. In Faka Union Bay the sediments were more variable but tended
toward intermediate among the categories analyzed, while farther west the
sediments were more evenly distributed among the categories listed.

Bays to the east of Faka Union Bay generally were dominated by large
expanses of low organic matter, low silt-clay sediments dominated by fine
grained sand fractions (Figs. 5 and 6). The general uniformity of substrate
conditions probably is due to the presence of only three major river sources
to the area (i.e., Barron, Ferguson, and Fakahatchee-East Rivers).
Approximately 90% of the benthic area between Fakahatchee and Chokoloskee had
sediments containing < 36% silt-clay (Table 1). Low organic matter levels
(< 6%) dominated this stratum with sediments containing between 7 and 12%
organic matter being second in areal abundance (Table 2). Within this
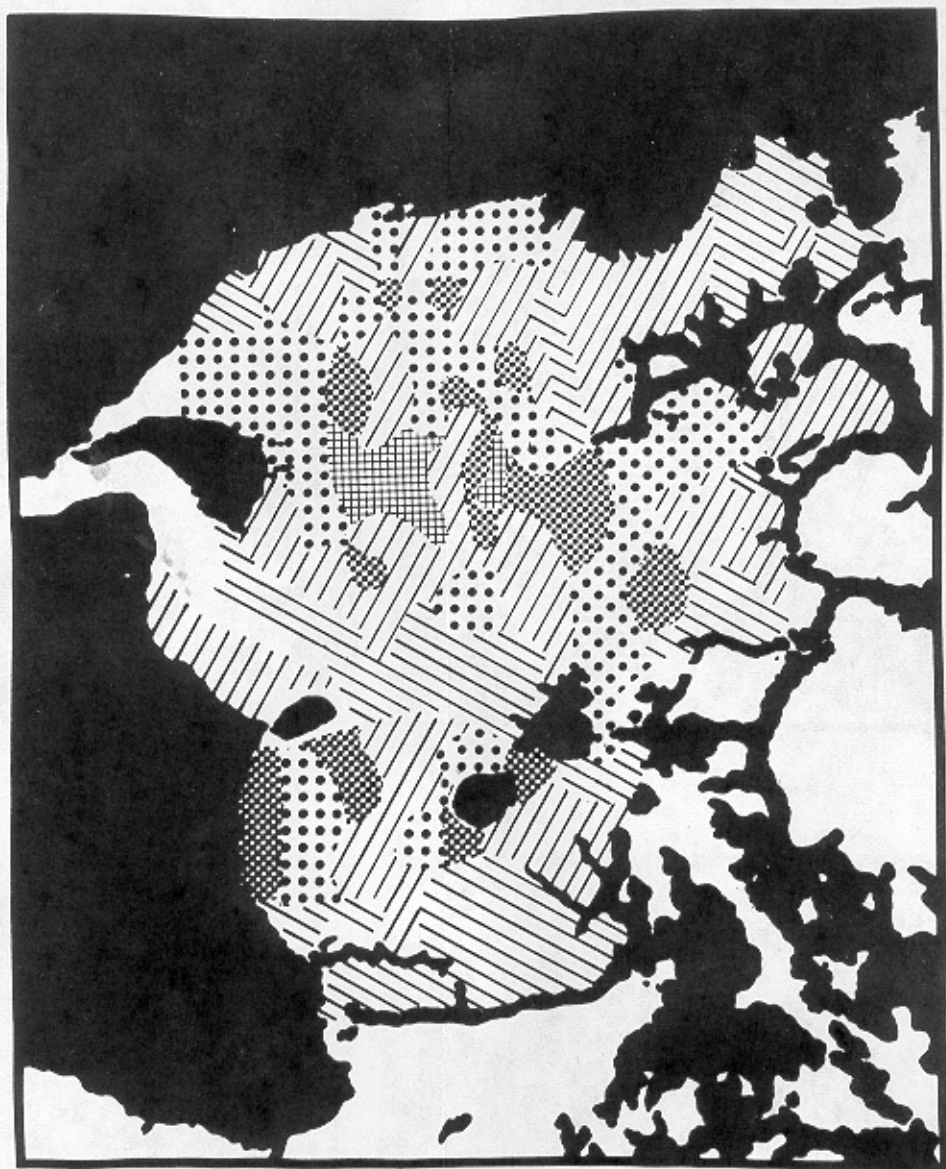
Figure 5. Areal distribution of percent silt-clay in Faka
Union Bay.
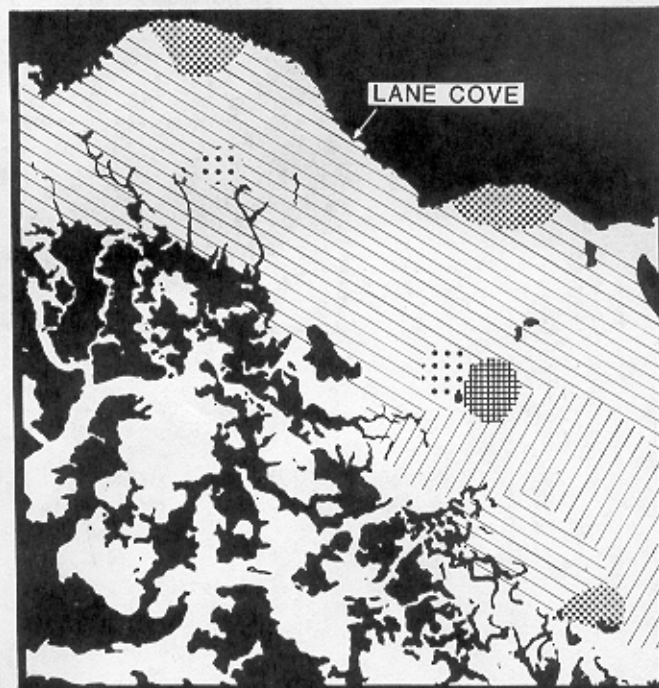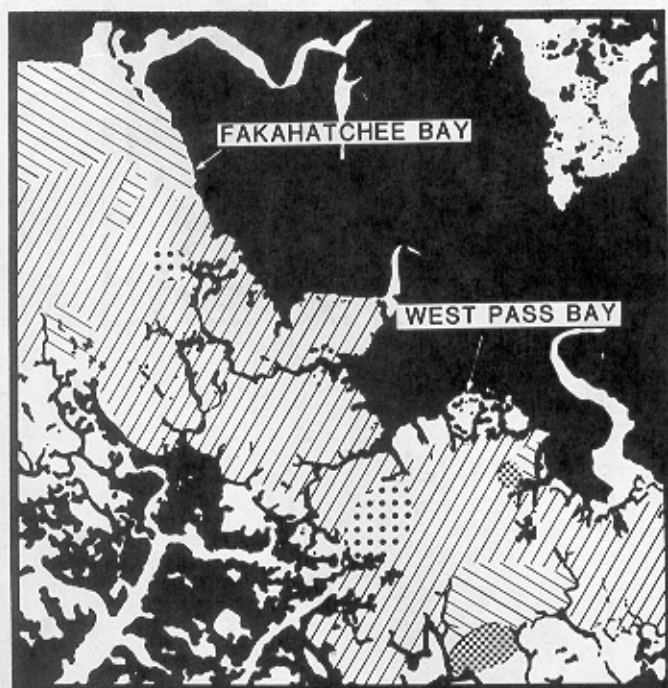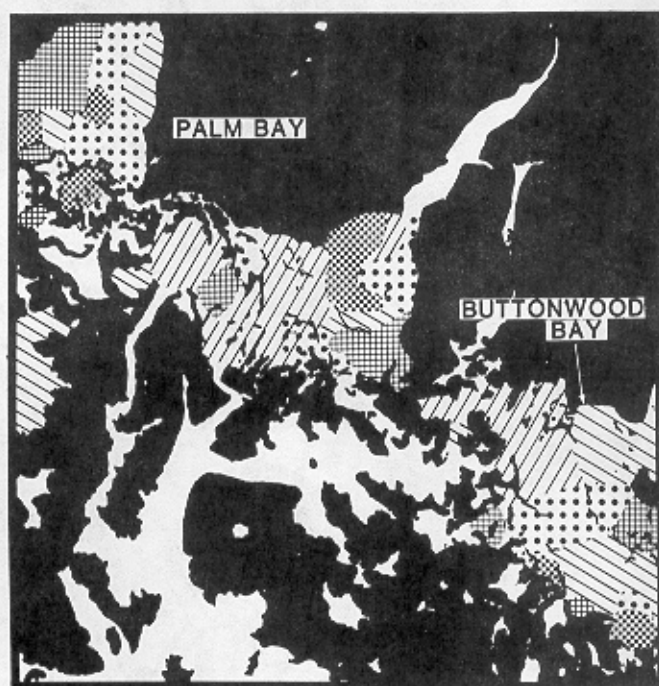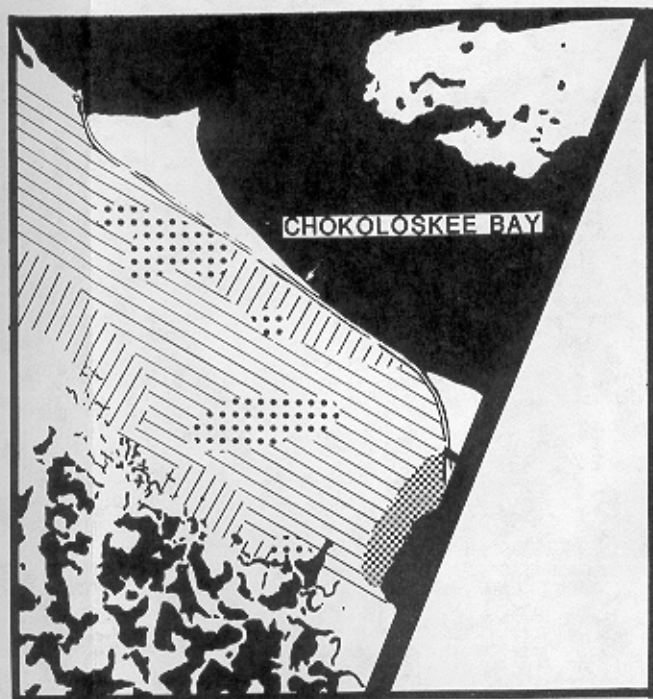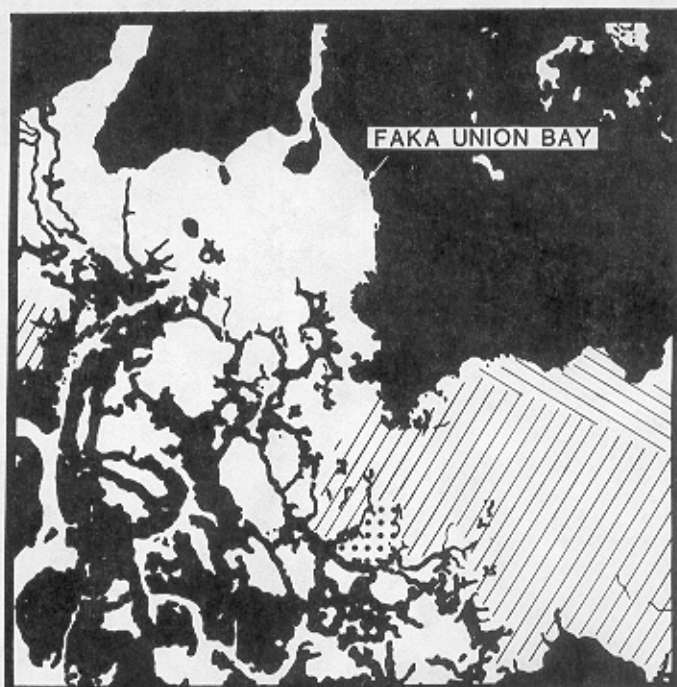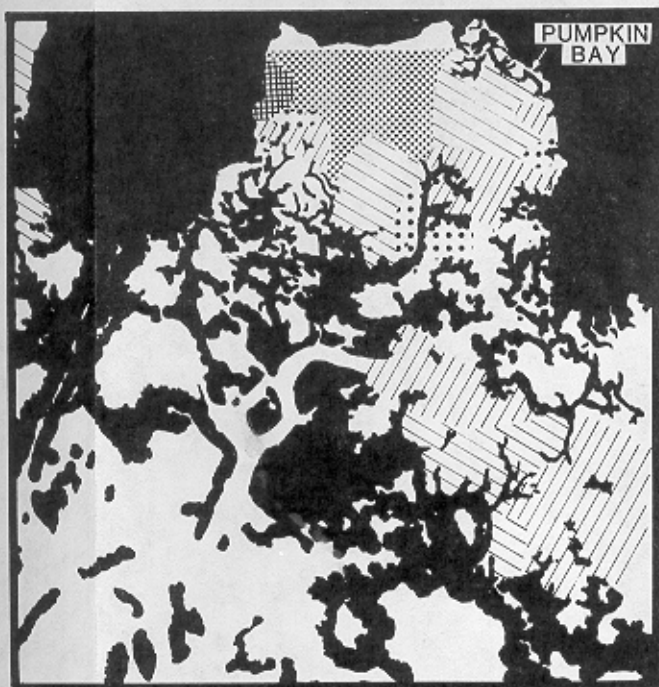
FIGURE 5

Areal distribution of percent silt-clay in the top 5 cm of
sediments collected in the Ten Thousand Island area.
Symbols denoting ranges in percent silt-clay are shown
below.

//////// $\leq$ 18%

\\\\\ 19-36%

....
.... 37-54%
....

55-72%

$\geq$ 73%

0   2000   4000
FEET
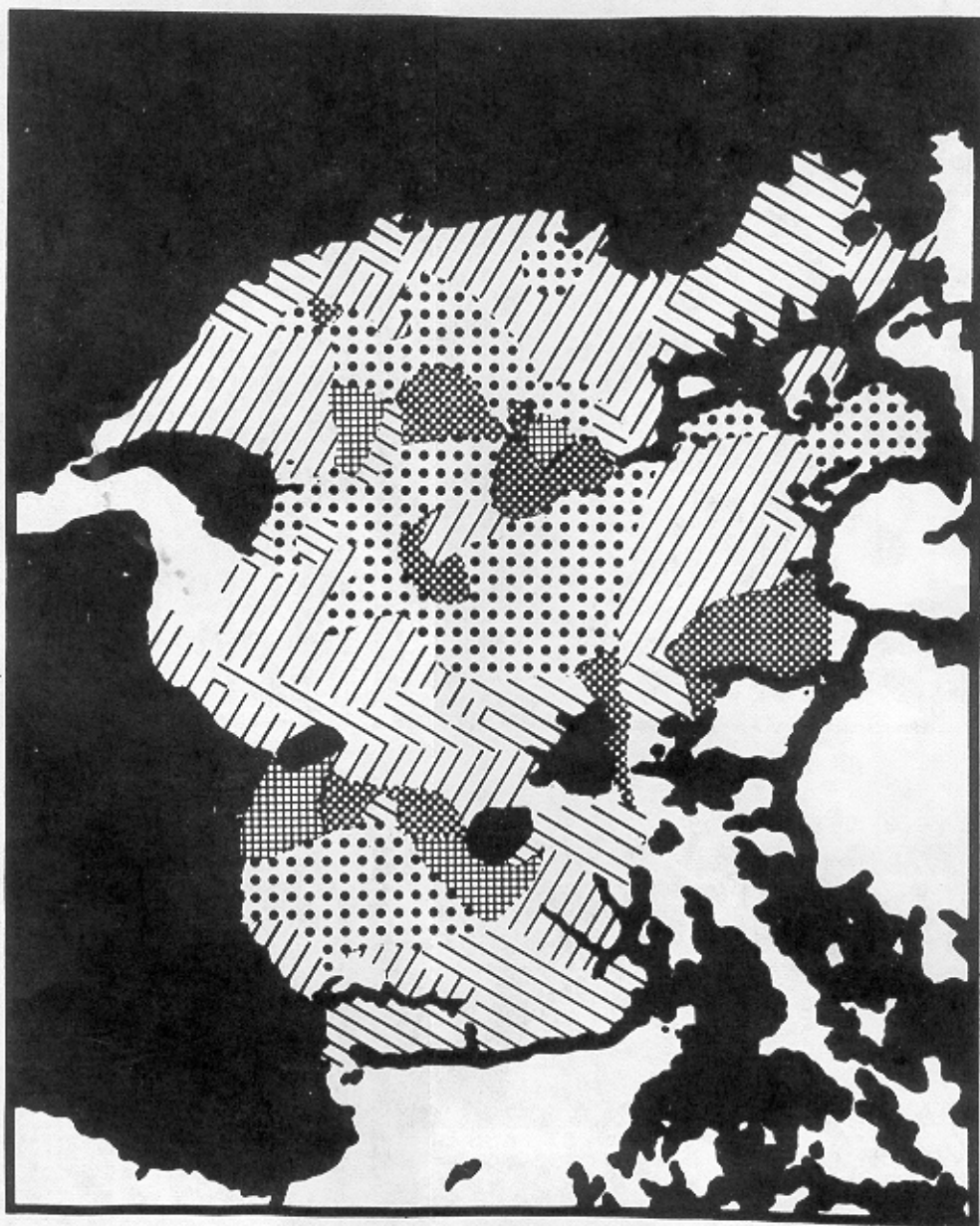
Figure 6. Areal distribution of percent organic matter in the top 5 cm of sediments in Faka Union Bay.
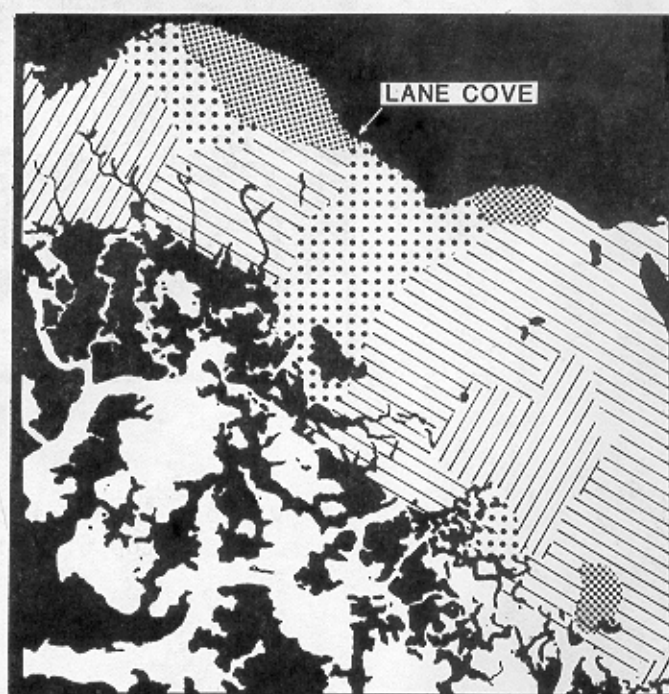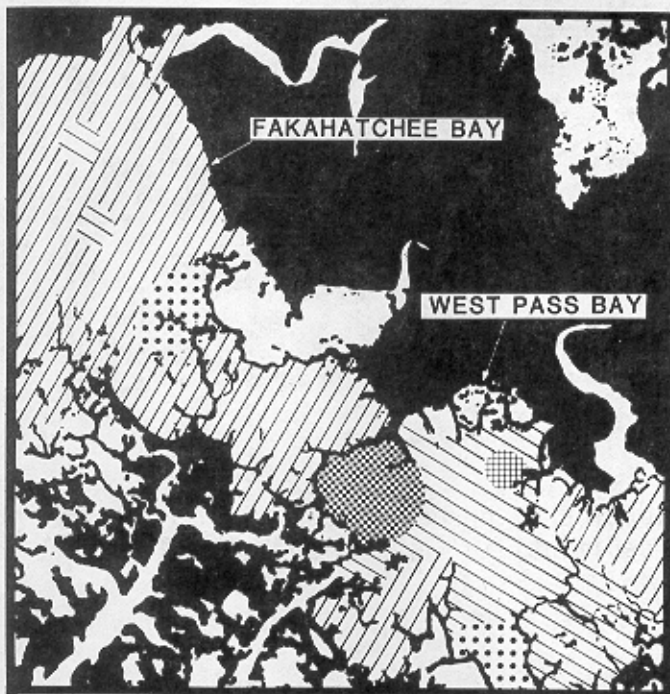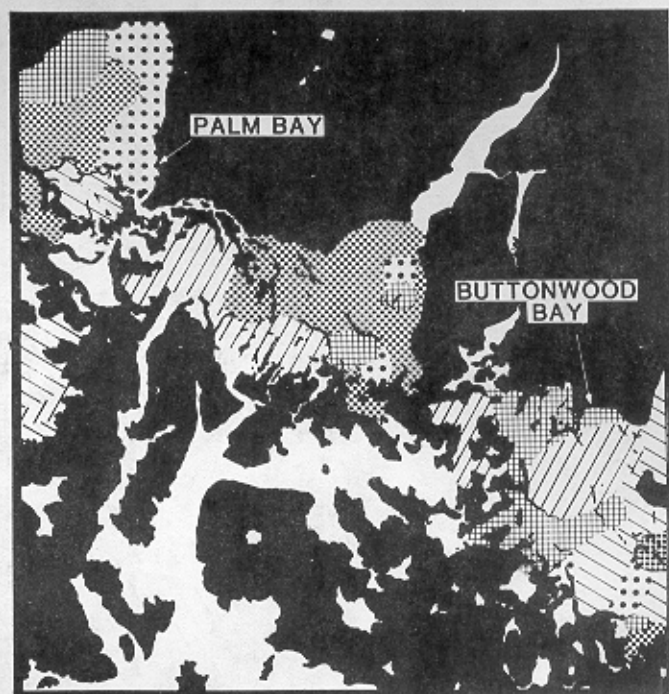
SUGAR BAY

PALM BAY

BUTTONWOOD BAY

FAKAHATCHEE BAY

WEST PASS BAY

LANE COVE

FIGURE 6

Areal distribution of percent organic matter in the top 5 cm
of sediments collected in the Ten Thousand Island area.
Symbols denoting ranges in percent organic matter are shown
below.

///////// ≤ 6%

\\\\\\ 7-12%

13-18%

19-24%

≥ 25%

0   2000   4000
FEET

Table 1. Areal distribution of percent silt-clay in the top 5 cm of
sediments collected from three strata sampled. Faka Union Bay
(stations 1-16), bays to the east of Faka Union Bay (stations
17-32), and bays to the west of Faka Union Bay (stations 33-48).
A total of 96 samples were taken in each stratum.

Percent Silt-Clay	STRATUM		
	Faka Union Bay	East Bays (Area Percent)	West Bays
< 18	2	47	32
19 - 36	28	45	30
37 - 54	25	5	15
55 - 72	35	3	12
> 73	10	< 1	11

Table 2. Areal distribution (percent) of sediment organic matter within the three strata sampled: Faka Union Bay (stations 1-16), bays to the east of Faka Union Bay (stations 17-32), and bays to the west of Faka Union Bay (stations 33-48). A total of 96 samples were taken in each stratum.

Percent Organic Matter	STRATUM		
	Faka Union Bay	East Bays	West Bays
	(Area Percent)		
< 6	23	46	24
7 - 12	36	38	26
13 - 18	26	11	10
19 - 24	10	4.7	28
> 25	5	< 1	12

stratum there was an obvious transition in the vicinity of the Ferguson River. To the east the sediments were primarily intermediate in both silt-clay and organic matter while to the west in Fakahatchee Bay the sediments were primarily low in both parameters. Small areas of generally high silt-clay and organic matter levels were evident to the west of the Barron River, suggesting this to be a major depositional area.

Within Faka Union Bay there was evidence of scouring by currents as well as evidence for areas of major sediment deposition. Only a small portion of the bay had low (< 18%) or extremely high (> 73%) silt-clay sediments, and intermediate organic levels predominated. Along the Faka Union Channel running through the western half of the bay, low levels of both organic matter and silt-clay were characteristic (Figs. 5 and 6). Organic matter and silt-clay levels also were low (relative to other parts of the system) at the junctures with Fakahatchee Bay on the east and the Wood River on the west. The central portion of the bay, however, displayed consistent high silt-clay and organic matter levels, strongly suggesting this as a major depositional area. These observations differ from Carter et al. (1973) who reported major organic and total sedimentation rate isopleths adjacent to the Faka Union Canal and at the juncture of Faka Union and Fakahatchee Bays. Differences at this pass area may simply be a function of station location and bottom areas sampled in the two studies; during our study, six bottom samples were taken along the pass. However, our observation of strong currents at the juncture between the bays leads us to believe sediment deposition in these areas is low.

Stratum III, the bay system to the west of Faka Union Bay, displayed more similarity in areal extent (i.e., percent of the area) of

sediment organic matter and silt-clay levels than occurred in either Faka Union Bay or the bay system to the east. Both organic matter and silt-clay levels were highest near the head of a bay and decreased seaward (Figs. 5 and 6). Based on these sediment characteristics, Pumpkin, Buttonwood, and Palm Bays all appear to be depositional systems having slower currents and possibly less overall water exchange than other bay areas sampled in Stratum III.

Relative Abundance of Fish: For the summaries and analyses to follow, surface and otter trawl catches at a given station and time were combined. This facilitated data entry and analysis, but because the trawls were of different dimensions, the combined catch cannot be regarded as a measure of numbers or biomass per unit area.

A total of 77,328 individuals distributed among 71 species and 33 families were collected by surface and otter trawls during the seven surveys of 1982 and 1983. The fish species collected are provided in Table 3, and their relative abundances are shown in Table 4. The overall wet weight biomass of fish was 85,295 g for the seven surveys and is shown for each species and survey in Table 4.

The ten dominant species for the overall study, listed in decreasing order of relative abundance were: bay anchovy (<u>Anchoa</u> <u>mitchilli</u>), striped anchovy (<u>A</u>. <u>hepsetus</u>), yellowfin menhaden (<u>Brevoortia</u> <u>smithi</u>), rough silverside (<u>Membras</u> <u>martinica</u>), silver perch (<u>Bairdiella</u> <u>chrysoura</u>), pinfish (<u>Lagodon</u> <u>rhomboides</u>), silver jenny (<u>Eucinostomus</u> <u>gula</u>), pigfish (<u>Orthopristis</u> <u>chrysoptera</u>), spotfin mojarra (<u>Eucinostomus</u> <u>argenteus</u>), and sand seatrout (<u>Cynoscion</u> <u>arenarius</u>). Generally, these species also dominated the overall catch reported for Faka Union Bay and Fakahatchee Bay by Carter et al.

Table 3. Fish species collected in the Ten Thousand Island area between Goodland Bay and Chokoloskee Bay during seven surveys using surface and bottom trawls. Numbers adjacent to species name should be used in conjunction with tables in which species are listed by number rather than name.

1.	Anchoa mitchilli	39.	Menidia beryllina
2.	Anchoa hepsetus	40.	Opsanus beta
4.	Eucinostomus argenteus	41.	Gobiosoma robustum
5.	Eucinostomus gula	42.	Gobionellus shufeldti
6.	Symphurus plagiusa	43.	Scaridae sp.
7.	Achirus lineatus	44.	Mugil curema
8.	Cynoscion arenarius	45.	Mugil cephalus
9.	Cynoscion nebulosus	46.	Strongylura timucu
10.	Bairdiella chrysoura	47.	Sphoeroides nephelus
11.	Lagodon rhomboides	48.	Chaetodipterus faber
12.	Archosargus probatocephalus	49.	Hippocampus zosterae
13.	Orthopristis chrysoptera	50.	Microgobius thalassinus
14.	Synodus foetens	51.	Prionotus scitulus
15.	Opisthonema oglinum	52.	Menticirrhus saxatilis
16.	Chloroscombrus chrysurus	53.	Paralichthys albigutta
17.	Menticirrhus americanus	54.	Gobiosoma bosci
18.	Menticirrhus littoralis	55.	Etropus crossotus
19.	Microgobius gulosus	56.	Elops saurus (Leptocephalus)
20.	Gobionellus smaragdus	57.	Mugil sp. (Larvae)
21.	Membras martinica	58.	Sciaenops ocellata
22.	Leiostomus xanthurus	59.	Lucania parva
23.	Strongylura marina	61.	Gobionellus boleosoma
24.	Hyporhamphus unifasciatus	62.	Diplectrum formosum
25.	Oligoplites saurus	63.	Ancylopsetta quadrocellata
26.	Brevoortia smithi	64.	Chilomycterus schoepfi
28.	Harengula pensacolae	65.	Ophichthus gomesi
29.	Arius felis	66.	Lutjanus synagris
30.	Bagre marinus	67.	Elops saurus (Adult)
31.	Gambusia affinis	68.	Floridichthys carpio
32.	Trinectes maculatus	69.	Myrophis punctatus
33.	Syngnathus scovelli	70.	Ogcocephalus radiatus
34.	Prionotus tribulus	71.	Pogonias cromis
35.	Caranx hippos	72.	Monacanthus hispidus
37.	Syngnathus louisianae	73.	Chasmodes saburrae
38.	Strongylura notata	74.	Stellifer lanceolatus
		75.	Diapterus plumieri

Table 4. Numbers and biomass of individual species collected in seven surveys during 1982 and 1983 in the bay system between Goodland and Chokohoskee, Florida. Refer to Table 3 for species code. Biomass values in grams wet weight.

Species Code	July 82 No.	July 82 Wt.	August 82 No.	August 82 Wt.	September 82 No.	September 82 Wt.	February 83 No.	February 83 Wt.	May 83 No.	May 83 Wt.	June 83 No.	June 83 Wt.	August 83 No.	August 83 Wt.	Sum No.	Sum Wt.
1	9538.0	4237.43	1224.0	723.07	7784.0	2653.40	3961.0	803.72	12309.0	2114.23	2581.0	754.88	1098.0	242.72	38498	11529
2	229.0	501.81	73.0	239.88	167.0	691.31	-	-	9077.0	1973.88	2302.0	770.11	47.0	91.07	11895	4268
4	189.0	679.15	68.0	487.10	18.0	151.30	6.0	62.91	43.0	328.62	58.0	222.10	25.0	85.24	407	2016
5	559.0	2131.32	840.0	3967.14	227.0	1717.39	39.0	399.24	84.0	941.46	141.0	1211.11	554.0	2265.99	2444	12633
6	154.0	159.71	82.0	180.52	37.0	124.86	9.0	10.93	7.0	13.65	14.0	9.67	49.0	84.20	352	583
7	18.0	9.36	20.0	9.10	3.0	1.86	2.0	1.44	2.0	2.43	-	-	5.0	16.26	50	40
8	187.0	370.17	32.0	171.73	53.0	141.35	-	-	23.0	71.81	37.0	65.51	39.0	36.14	371	856
9	5.0	3.92	12.0	21.11	5.0	34.18	-	-	1.0	0.23	12.0	11.51	12.0	40.78	47	112
10	320.0	1780.65	176.0	2239.90	317.0	6542.75	62.0	733.95	535.0	1165.04	1010.0	1025.39	322.0	685.01	2752	14173
11	85.0	653.39	39.0	288.49	10.0	197.81	1002.0	236.10	724.0	1569.86	611.0	2248.78	168.0	1281.71	2639	6476
12	2.0	17.78	4.0	139.44	2.0	22.26	2.0	0.18	36.0	110.62	24.0	14.20	4.0	72.94	74	377
13	8.0	71.63	2.0	37.29	-	-	29.0	5.02	257.0	177.34	164.0	482.83	7.0	83.53	467	857
14	5.0	82.11	7.0	119.86	3.0	122.77	37.0	49.31	78.0	517.02	98.0	557.41	53.0	653.79	281	2102
15	123.0	162.41	-	-	27.0	91.94	-	-	64.0	26.63	12.0	10.58	-	-	226	292
16	168.0	69.23	2.0	0.80	5.0	1.90	-	-	-	-	2.0	0.49	5.0	0.31	182	73
17	2.0	7.42	6.0	74.03	3.0	70.21	-	-	6.0	9.31	12.0	5.42	4.0	8.10	33	174
18	7.0	27.24	2.0	10.69	9.0	113.67	-	-	-	-	1.0	19.31	-	-	19	171
19	15.0	4.99	12.0	3.66	-	-	6.0	1.0	5.0	0.42	4.0	1.10	8.0	1.69	50	13
20	4.0	6.52	-	-	-	-	12.0	15.89	3.0	5.15	-	-	-	-	19	28
21	118.0	143.61	101.0	158.27	140.0	279.04	4.0	14.88	3087.0	537.81	2792.0	934.11	819.0	1218.89	7061	3287
22	-	-	-	-	-	-	-	-	23.0	340.19	35.0	739.06	3.0	107.92	61	1187
23	8.0	195.02	-	-	-	-	-	-	-	-	-	-	-	-	8	195
24	58.0	181.75	5.0	30.46	19.0	261.58	16.0	376.45	5.0	6.33	115.0	325.25	19.0	176.89	237	1359
25	20.0	55.88	11.0	20.69	10.0	20.53	-	-	1.0	0.01	13.0	9.03	29.0	48.0	84	154
26	16.0	180.40	1.0	19.78	67.0	1260.26	5831.0	396.79	1344.0	351.99	17.0	30.34	39.0	159.02	7315	2399
28	53.0	145.45	9.0	43.68	28.0	199.85	2.0	32.18	-	-	-	-	4.0	20.02	96	441
29	8.0	1460.84	233.0	1620.69	11.0	878.90	3.0	587.16	8.0	993.31	16.0	622.26	3.0	247.10	282	6410
30	5.0	424.84	22.0	208.30	19.0	405.72	-	-	3.0	420.91	-	-	3.0	990.85	52	2451
31	1.0	0.01	-	-	-	-	-	-	-	-	-	-	-	-	1	0.01
32	2.0	10.45	2.0	11.0	2.0	15.33	-	-	-	-	-	-	-	-	6	37
33	18.0	4.73	11.0	3.01	1.0	0.09	70.0	17.34	58.0	12.19	148.0	41.90	35.0	7.13	341	86
34	1.0	0.08	-	-	1.0	0.46	4.0	2.86	-	-	-	-	1.0	0.19	7	4
35	2.0	33.61	-	-	-	-	-	-	-	-	-	-	-	-	2	34
37	1.0	0.52	-	-	-	-	10.0	3.85	8.0	3.92	3.0	1.87	-	-	22	10
38	18.0	363.62	48.0	938.32	53.0	444.08	10.0	369.16	41.0	1444.22	7.0	337.63	16.0	191.81	193	4089
39	1.0	1.02	1.0	2.0	-	-	-	-	-	-	-	-	-	-	2	3
40	3.0	108.09	-	-	-	-	1.0	3.63	1.0	31.02	19.0	58.45	2.0	2.14	26	203
41	5.0	1.73	15.0	2.36	5.0	0.26	34.0	8.55	19.0	2.93	87.0	20.93	38.0	7.77	203	45
42	2.0	0.23	-	-	2.0	0.29	-	-	-	-	-	-	-	-	4	0.5
43	1.0	0.19	-	-	-	-	-	-	-	-	-	-	-	-	1	0.2
44	42.0	264.22	-	-	-	-	2.0	99.10	13.0	133.28	1.0	50.41	-	-	58	547
45	-	-	-	-	-	-	1.0	271.38	1.0	282.03	-	-	-	-	2	553
46	1.0	3.72	17.0	497.82	6.0	141.60	8.0	459.26	53.0	424.22	26.0	348.42	21.0	548.70	132	2424
47	1.0	4.60	-	-	-	-	7.0	42.32	13.0	43.07	2.0	2.37	-	-	23	92
48	1.0	6.80	1.0	0.94	1.0	0.69	2.0	254.67	2.0	121.93	4.0	5.63	2.0	13.64	13	404
49	-	-	2.0	0.12	-	-	-	-	2.0	0.14	3.0	0.51	-	-	7	0.8
50	-	-	1.0	0.20	3.0	0.48	30.0	5.36	2.0	0.41	2.0	0.16	8.0	0.50	46	7
51	-	-	1.0	2.51	-	-	1.0	0.61	8.0	26.28	4.0	2.63	1.0	22.11	15	54
52	-	-	2.0	22.69	-	-	-	-	-	-	1.0	7.97	-	-	3	31
53	-	-	1.0	68.10	-	-	2.0	0.63	9.0	173.74	6.0	295.75	3.0	179.08	21	717
54	-	-	-	-	1.0	0.29	-	-	-	-	3.0	0.88	-	-	4	1
55	-	-	-	-	1.0	6.43	1.0	6.13	-	-	5.0	10.93	5.0	12.53	12	36
56	-	-	-	-	-	-	120.0	24.78	-	-	-	-	-	-	120	25
57	-	-	-	-	-	-	20.0	2.46	3.0	0.18	-	-	-	-	23	3
58	-	-	-	-	-	-	1.0	0.18	-	-	-	-	-	-	1	0.2
59	-	-	-	-	-	-	1.0	0.04	2.0	0.08	4.0	0.60	4.0	0.31	11	1
61	-	-	-	-	-	-	1.0	0.02	-	-	-	-	-	-	1	0.02
62	-	-	-	-	-	-	-	-	1.0	0.27	-	-	-	-	1	0.3
63	-	-	-	-	-	-	-	-	1.0	119.07	-	-	-	-	1	119
64	-	-	-	-	-	-	-	-	3.0	296.63	5.0	8.51	2.0	252.69	10	558
65	-	-	-	-	-	-	-	-	1.0	59.40	-	-	-	-	1	59
66	-	-	-	-	-	-	-	-	2.0	27.02	-	-	-	-	2	27
67	-	-	-	-	-	-	-	-	1.0	138.80	-	-	-	-	1	139
68	-	-	-	-	-	-	-	-	1.0	0.04	-	-	-	-	1	0.04
69	-	-	-	-	-	-	-	-	1.0	0.10	-	-	-	-	1	0.1
70	-	-	-	-	-	-	-	-	-	-	2.0	178.23	-	-	2	178
71	-	-	-	-	-	-	-	-	-	-	1.0	76.22	1.0	72.18	2	148
72	-	-	-	-	-	-	-	-	-	-	1.0	0.63	-	-	1	0.6
73	-	-	-	-	-	-	-	-	-	-	4.0	0.77	-	-	4	0.8
74	-	-	-	-	-	-	-	-	-	-	1.0	0.25	-	-	1	0.3
75	-	-	-	-	-	-	-	-	-	-	-	-	1.0	1.01	1	1

(1973), although not necessarily in the same order. Carter et al. (1973), using the same two gears plus a beach seine, reported anchovy, yellowfin menhaden, scaled sardine (Harengula pensacolae), pinfish, striped anchovy, silver perch, and silver jenny as the dominant eight species in their collections. The only major differences between dominants in the two studies, made about 10 years apart, therefore, were M. martinica and H. pensacolae. Although not a dominant species, mullet appeared more important in catches by Carter et al. (1973) than was true for our collections (Tables 3 and 4).

Those species dominating the overall catch numerically did not necessarily dominate the overall biomass, and only five species were common to the top 10 in both categories. The ten species contributing most to the biomass in decreasing order were: silver perch, silver jenny, bay anchovy, pinfish, sea catfish (Arius felis), striped anchovy, red needlefish (Strongylura notata), rough silverside, gafftopsail catfish (Bagre marinus), and timucu (Strongylura timucu).

Fewer individuals and generally fewer species were collected during the 1982 wet season when area-wide salinity was depressed due to the much higher than normal rainfall (15-in) during the June-August period. A total of just over 24,000 individuals was collected in summer 1982 compared to almost 42,000 individuals in summer 1983. The average number of species collected during the low salinity year was 38 (range 34-43) compared to 44 (range 39-48) in summer 1983. Although bay anchovy dominated the catch during both years, it represented almost 77% of the 1982 catch while representing only 38% of the 1983 catch. Five species, present in low numbers in 1982, were not collected in 1983: mosquitofish (Gambusia affinis),

hogchoaker (Trinectes maculatus), crevalle jack (Caranx hippos), freshwater goby (Gobionellus shufeldti), and an unidentified scarid. Fourteen species that were not collected in 1982 were collected during summer 1983, although these represented only a small number (see Table 4). In addition to the two wet season sampling periods (3 surveys each), a survey was made during winter. Three species including red drum (Sciaenops ocellata) were collected in February that were not collected during either summer (Table 4). Ladyfish (Elops saurus) leptocephali were fourth in abundance for that entire collection, and never were collected at other times.

The two trawls were intended to complement one another and collect different components of the fish community, and to some extent this was the case. Anchovy, menhaden, silversides and needlefish, for example, were predominantly taken with the surface trawl whereas pinfish, pigfish, sand seatrout, and silver perch were usually taken by the otter trawl. However, the shallow depths (Mean depths: Strata I = 1.09 m, Strata II = 1.22 m, Strata III = 1.17 m) encountered over most of the study area caused considerable overlap in the portions of the water column sampled by the two trawls and as a consequence, benthic species were not infrequently taken with the surface trawl and pelagic species were sometimes collected with the otter trawl. Two thirds of the fish collected were recovered from the surface trawl.

Distribution of Fish Species Among Strata: A major purpose of the investigation was to determine if the fish community within Faka Union Bay differed in composition from the fish communities in the collateral bays not subject to the discharge from Faka Union Canal. We originally intended to address this question by utilizing certain types of multivariate statistical

analysis to determine if unique groups of fishes were confined in their occurrence to Faka Union Bay. The presence of a large number of zeros in the species-sample matrix, however, rendered the approach somewhat suspect, and we therefore sought a simpler analytical approach that would require fewer statistical assumptions and yet adequately address the question. We began by simply constructing a species by survey by strata matrix that indicated whether a given species was collected in a given strata in a given survey. Using this matrix we next constructed Venn diagrams depicting the co-occurrence of taxa for each of the six surveys conducted during the summer months (Fig. 7a). Each stratum is represented as a ring in a Venn diagram and the three rings intersect so that the number of taxa found in all strata is indicated within the intersection of all three rings, the number of taxa found in two of the three strata is indicated within the corresponding intersection of those two respective rings, and those taxa unique to a particular stratum are indicated within the appropriate ring outside of intersections with the other two.

Evidence of a fish community unique to Faka Union Bay would be revealed in the Venn diagrams by a substantial number of taxa in ring 1 outside the intersections with the other two strata. One might also expect to see relatively more taxa in the intersection between rings 2 and 3 and fewer in the intersections between rings 1 and 2 and between 1 and 3. An inspection of the diagrams for the six surveys, however, reveals no such pattern. Instead, from 44 to 53% of the taxa are shared among all three strata, and Stratum I contains _fewer_ unique taxa than one or both of the other two strata in _every_ survey. This pattern also held for the February 1983 survey when only one species, the darter goby (_Gobiosoma bosci_) was taken exclusively within Faka Union Bay.
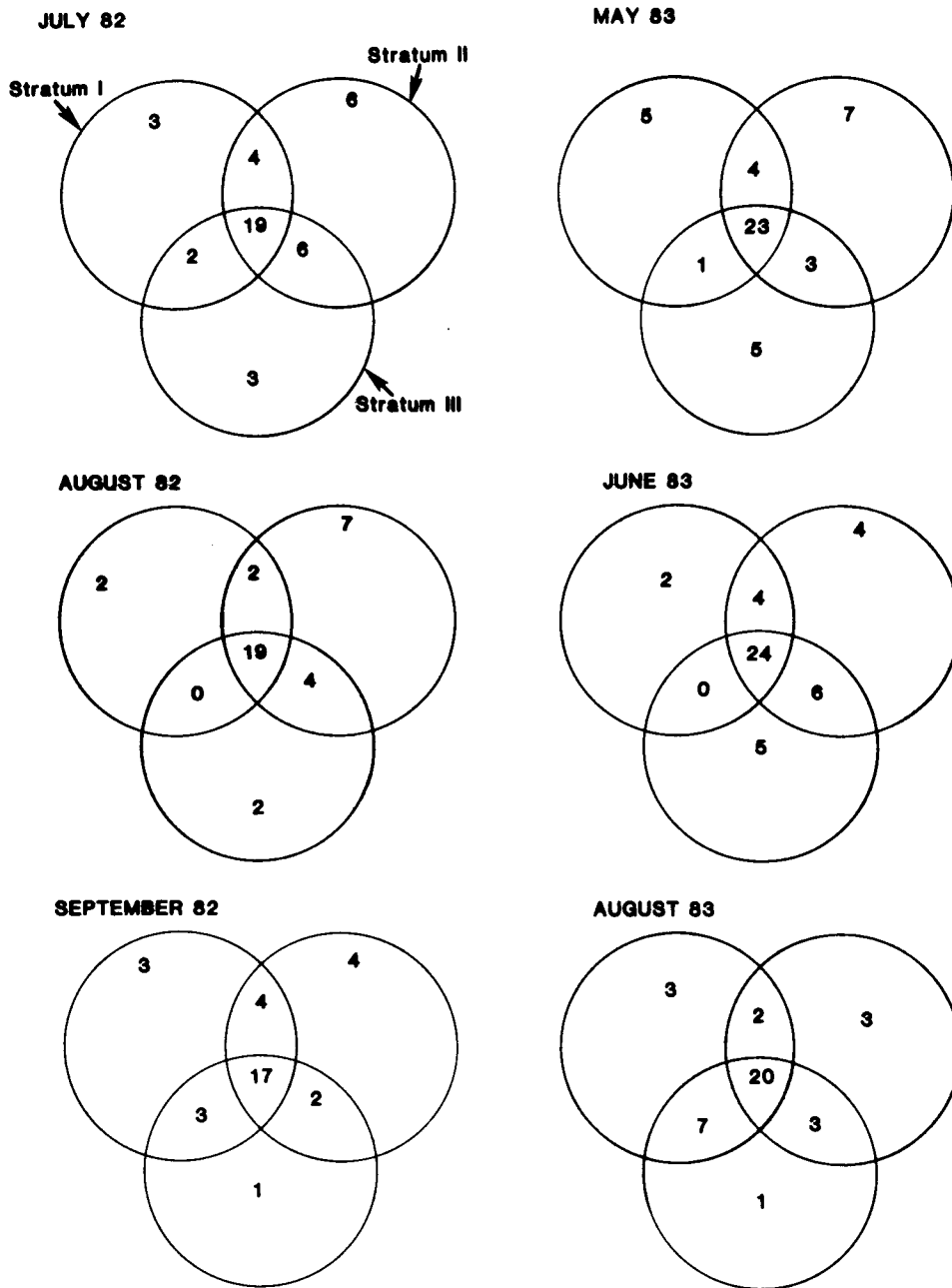
Figure 7a. Diagrammatic representations of the similarities and differences in numbers of fish species collected in the three sampling strata during the six surveys conducted in the summers of 1982 and 1983. See text for discussion.

If we postulate that to have biological meaning, a fish community must have continuity within the time frame of the study, then an additional Venn diagram of the species co-occurrences is warranted in which we exclude from consideration the species (34) that occurred in each stratum at least once, but not in every survey (see Table 4 for an assessment of those species). Those species that occurred in only one stratum are included within their respective rings outside the intersections. Those species that were found in only two of the three strata are placed in the appropriate intersections between two rings and the intersection among all three rings contain the truly ubiquitous species that were collected from every stratum on every survey (Fig. 7b). One is immediately struck by the symmetry of this diagram. Four species were shared between Stratum I and Stratum II: (Trinectes maculatus, Hippocampus zosterae, Lucania parva, and Pogonias cromis). Four species (Gobionellus smaragdus, Caranx hippos, Mugil curema, and Menticirrhus saxatilis) were shared between Stratum I and Stratum III, and another four species were encountered only in Strata II and III (Prionotus tribulus, Menidia beryllina, Opsanus beta, and Mugil sp.). There were seven ubiquitous species, and these not surprisingly were among the 11 most abundant fishes encountered in the study. These ubiquitous species were Anchoa mitchilli, A. hepsetus, Eucinostomus argenteus, E. gula, Symphurus plagiusa, Cynoscion arenarius, and Bairdiella chrysoura. Four species were collected exclusively in Faka Union Bay, but each was taken during only one survey. The same was true for the six species taken exclusively in Stratum II and the four species taken exclusively in Stratum III. The "once only" nature of the captures of these 14 species (see Table 4) and their observed distribution among the three strata is not inconsistent with the hypothesis
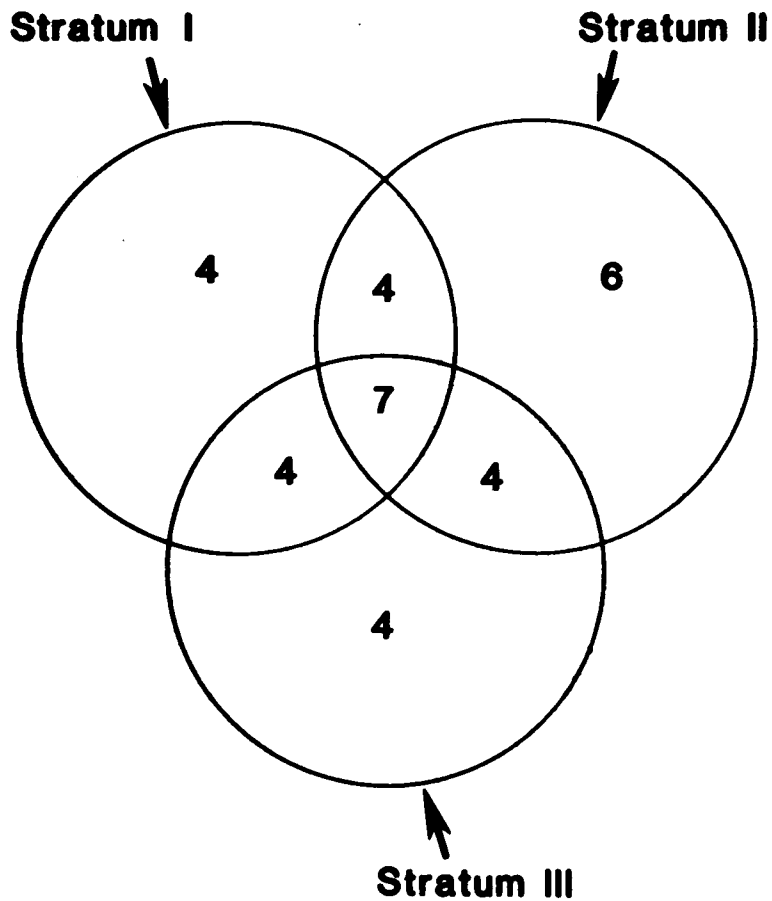
OVER ALL SURVEYS

Figure 7b. Diagrammatic representation of the overall similarities and differences in numbers of fish species collected from within the three strata during the summers of 1982 and 1983. See text discussion.

that they are simply uncommon and randomly distributed among the bays of the study area.

In general the number of species collected in each stratum on each occasion was similar. In terms of total numbers of species over all the surveys, there were 52, 55, and 53 taken in Strata I, II, and III, respectively. Thus, the evidence does not support the view that Faka Union Bay supports a taxonomically impoverished fish community, nor do the data provide evidence that a separate community of species preferring or tolerating lower salinity prevails within the bay. As discussed below, however, this does not mean that numbers of individuals did not vary significantly among the strata.

Comparison of Overall Numbers of Fish Over Space and Time: We begin our examination of numerical abundance of fish by considering all species together as a single combined variable. Such a combined variable, while obscuring potentially important differences among component species, offers advantages because the combined variable is likely to be more consistent with assumptions of conventional parametric statistical procedures than would the abundance data for a single species, especially a schooling fish. In addition, this approach will provide a more or less "global overview" of fish abundance before we examine the more complex and detailed information on individual species.

During each of the six surveys conducted during the summers of 1982 and 1983, fish were collected with the otter trawl and the surface trawl at 16 randomly selected locations within each of the three strata. The total number of fish in these 288 combined samples (surface and bottom trawl) were analyzed using analysis of variance to separate information from inherent

background noise (biological variation in this case). Fish density and biomass measurements with trawls are almost invariably skewed and our data are no exception. A number of transformations of the raw data were employed in an attempt to "normalize" the data and stabilize the variances across survey-stratum combinations (cells). None achieved the desired result and we therefore regard the statistical tests of hypotheses as approximations. The Welch and Brown-Forsythe tests do not require the usual assumptions concerning equality of within-cell variances. The statistical model for the analysis was a linear model incorporating two factors, survey and stratum, and their interaction. The analysis of variance is presented in Table 5 and total numbers of fish are shown in Table 6 and Figure 8.

Because the surveys were conducted in July, August, and September of 1982 and in May, June, and August of 1983. Simple comparisons between the two years would be misleading. However, in any case, the ANOVA revealed a significant interaction between strata and surveys and our focus should therefore be on the 18 totals for each stratum-survey combination rather than overall totals for strata, or for surveys. An examination of these totals (Table 6) shows that: (1) Stratum I consistently had the lowest densities of fish; and (2) the stratum with the highest densities changed from Stratum II in 1982 to Stratum III in 1983. This latter fact underscored the implication of the significant interaction that a comparison of the overall stratum totals would be without merit.

The rate of change in numbers over time was related to the magnitude of the abundance at the beginning of the time interval. For example, compare the magnitude of the changes in each of the strata over the period July to August 1982 or May to August 1983. Although the overall decrease in

Table 5. Analysis of variance of total numbers of fish (all species combined) taken during six surveys conducted during the summers of 1982 and 1983.

SOURCE	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
Survey	5	1,719,065	13.72	0.0000
Strata	2	1,227,594	9.80	0.0001
Interaction	10	280,543	2.24	0.0160
Error	270	125,252		
Lavene's test for equal variances	17,270		8.30	0.0000
One-way analysis of variance test statistics for within-group variances not assumed to be equal				
Welch	17,100		5.43	0.0000
Brown-Forsythe	17,95		6.51	0.0000

Table 6.   Distribution of fish numbers collected on each survey during the rainy season according to strata.   Sixteen-paired trawls were taken in each stratum during each survey.

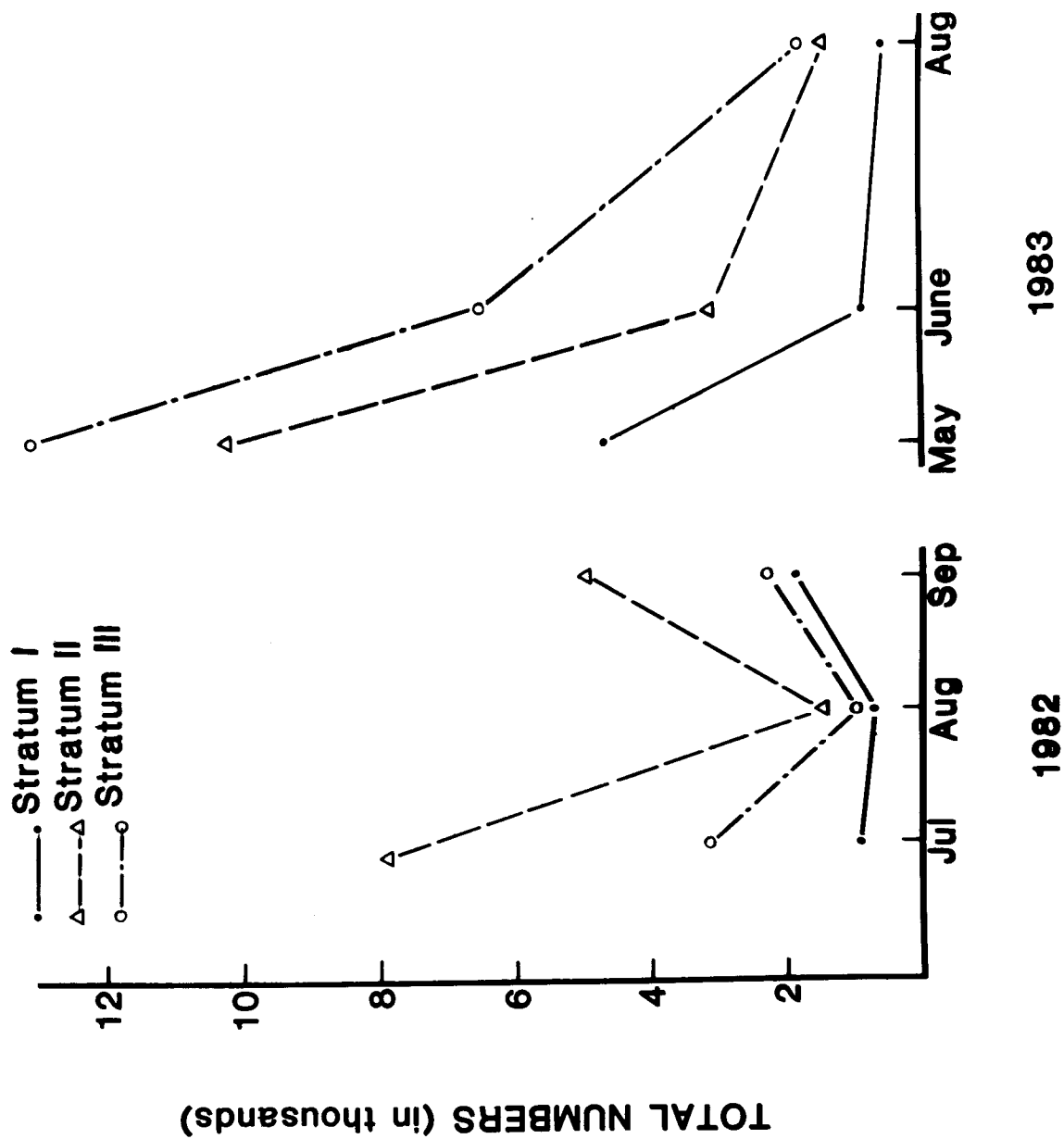|	Stratum I No	Stratum II No	Stratum III No
July 82	929	7911	3164
August 82	661	1468	956
Sept. 82	1831	4979	2230
YEAR TOTAL	3421	14,358	6350
May 83	4741	10,202	13,028
June 83	814	3095	6501
Aug. 83	512	1344	1613
YEAR TOTAL	6067	14,641	21,142

Figure 8. Total numbers of fish collected from each stratum during each survey conducted in the summers of 1982 and 1983. Each point is based on the combined catch from the otter trawl and surface trawl at 16 randomly selected locations within each stratum.

abundance was proportionately similar in all strata from May to August 1983 (i.e., 87-89% decrease), proportionally the greatest reduction in numbers occurred in Faka Union Bay between May and June. Here, the abundance of fish decreased by 83% relative to 70% (Stratum II) and (50%) (Stratum III) in the other bays. With the onset of the rainy period in late May and June, Faka Union Bay responded more rapidly than either of the other strata in reduced bay-wide salinities (Fig. 3). The relative similarity in the values for August 1982 and August 1983 and the upward trend from August to September of 1982 suggests that in this region, numerical abundance in the annual cycle may reach a minimum during late summer.

The taxa that numerically dominated our overall collections within each of the three strata were remarkable similar. The top 10 are listed for each stratum in Table 7. Seven were common to all strata. These included four pelagic species (A. mitchilli, A. hepsetus, B. smithi, and M. martinica) and three species that display a more benthic existance (E. gula, L. rhomboides, and S. plagiusa). The sea catfish (A. felis) and spotfin mojarra (E. argenteus) were among the dominant species only in Faka Union Bay, and the blackcheeked tonguefish (S. plagiusa) was among the 10 dominant species in Strata II and III but not in Faka Union Bay. Pigfish (O. chrysoptera) and gulf pipefish (S. scovelli) were among the dominants only in Stratum II, while the sand seatrout (C. arenarius) was among the dominants in both the bay strata adjacent to Faka Union Bay but, it was not among the dominants in Faka Union Bay. The Atlantic thread herring (O. oglinum) was a dominant species in Stratum III but not elsewhere.

Within the framework of the study, one of our objectives was to determine how the fish community in Faka Union Bay differed from that of the

Table 7. Top 10 species of fish collected in each strata overall. Species are listed in decending order of abundance and the value in parentheses represents the total number caught in that strata.

Strata I	Strata II	Strata III
A. mitchilli (5229)	A. mitchilli (19539)	A. mitchilli (13727)
A. hepsetus (2012)	A. hepsetus (3490)	A. hepsetus (6393)
B. smithi (685)	B. smithi (3271)	M. martinica (4674)
B. chrysoura (652)	M. martinica (2200)	B. smithi (3359)
E. gula (538)	B. chrysoura (1463)	L. rhomboides (1555)
L. rhomboides (377)	E. gula (899)	E. gula (1007)
A. felis (246)	L. rhomboides (717)	B. chrysoura (637)
E. argenteus (237)	O. chrysoptera (331)	O. oglinum (149)
M. martinica (187)	S. scovelli (220)	S. plagiusa (124)
S. plagiusa (120)	C. arenarius (160)	C. arenarius (114)

collateral bay system of the Ten Thousand Islands. While there was a similarity in the taxonomic composition among the three strata, there was a dissimilarity in the overall abundance of fish collected. If the collateral bays can be regarded as generally unimpacted systems, the numerical abundances of species for these bays (Strata II and III) provide a basis for comparison of the observed species abundances in Faka Union Bay. Provided in Table 8 is a listing of the species (by numeric code), and the total number collected with an abundance rank assigned to each. The expected number of species (based on average abundances in Strata II and III) and the observed number of each in Faka Union Bay samples are shown. The percent by which the observed value for each species deviates from the expected also is given and provides a measure of how the fish community in Faka Union Bay differed from the remainder of the sampling area. Of the most abundant species, $\underline{A}$. $\underline{mitchilli}$, $\underline{A}$. $\underline{hepsetus}$, $\underline{L}$. $\underline{rhomboides}$, $\underline{M}$. $\underline{martinica}$, $\underline{B}$. $\underline{smithi}$, $\underline{O}$. $\underline{chrysoptera}$, $\underline{E}$. $\underline{gula}$, $\underline{B}$. $\underline{chrysoura}$, and $\underline{C}$. $\underline{chrysurus}$ were collected in Faka Union Bay in substantially lower numbers than we would have expected based on their abundance in the collateral bays. $\underline{E}$. $\underline{argenteus}$ and $\underline{A}$. $\underline{felis}$ were taken in disproportionately higher numbers.

Distribution of Fish Biomass: Wet weights as well as numbers of individuals were obtained for each species of fish for each of the 288 trawled samples collected during the wet seasons of 1982 and 1983 (Table 4 and Fig. 9). Total biomass was examined in the same way that we analyzed total numbers of fish.

The ANOVA for total fish biomass is given in Table 9 and the total biomasses by stratum and survey are given in Table 10. The ANOVA failed to detect significant interactions or significant differences in biomass among surveys despite the fact that, for example, biomass was lowest for Stratum I in

Table 8. Relative abundance and rank of top 30 species collected in the
Ten Thousand Island area sampled in summer 1982 and 1983.
Expected abundances for Faka Union Bay are the averages of the
other two strata. Sign on the % deviation indicates $\geq$ (+) or
$\leq$ (-) expected.

| Species Code | Total Number | Abundance Rank | FAKA UNION BAY | | |
			Expected	Observed	% Deviation
1	38495	1	16633	5229	-68
2	11895	2	4942	2012	-59
4	407	9	85	237	+178
5	2444	7	953	538	-43
6	352	11	116	120	+ 3
7	50	28.5	20	9	-56
8	371	10	137	97	-29
9	47	30	17	12	-31
10	2752	5	1050	652	-38
11	2639	6	1131	377	-67
12	74	24	27	19	-30
13	467	8	220	27	-88
14	281	14	97	86	-12
15	226	16	85	55	-36
16	182	19	90	1	-99
19	50	28.5	16	18	+12
21	7061	4	3437	187	-94
22	61	25	28	4	-86
24	237	15	100	36	-64
25	84	23	27	29	+ 5
26	7315	3	3315	685	-79
28	96	22	44	7	-84
29	282	13	18	246	+1266
30	52	27	23	5	-79
33	341	12	142	56	-61
38	193	18	59	74	+24
41	203	17	83	36	-57
44	58	26	28	1	-96

44
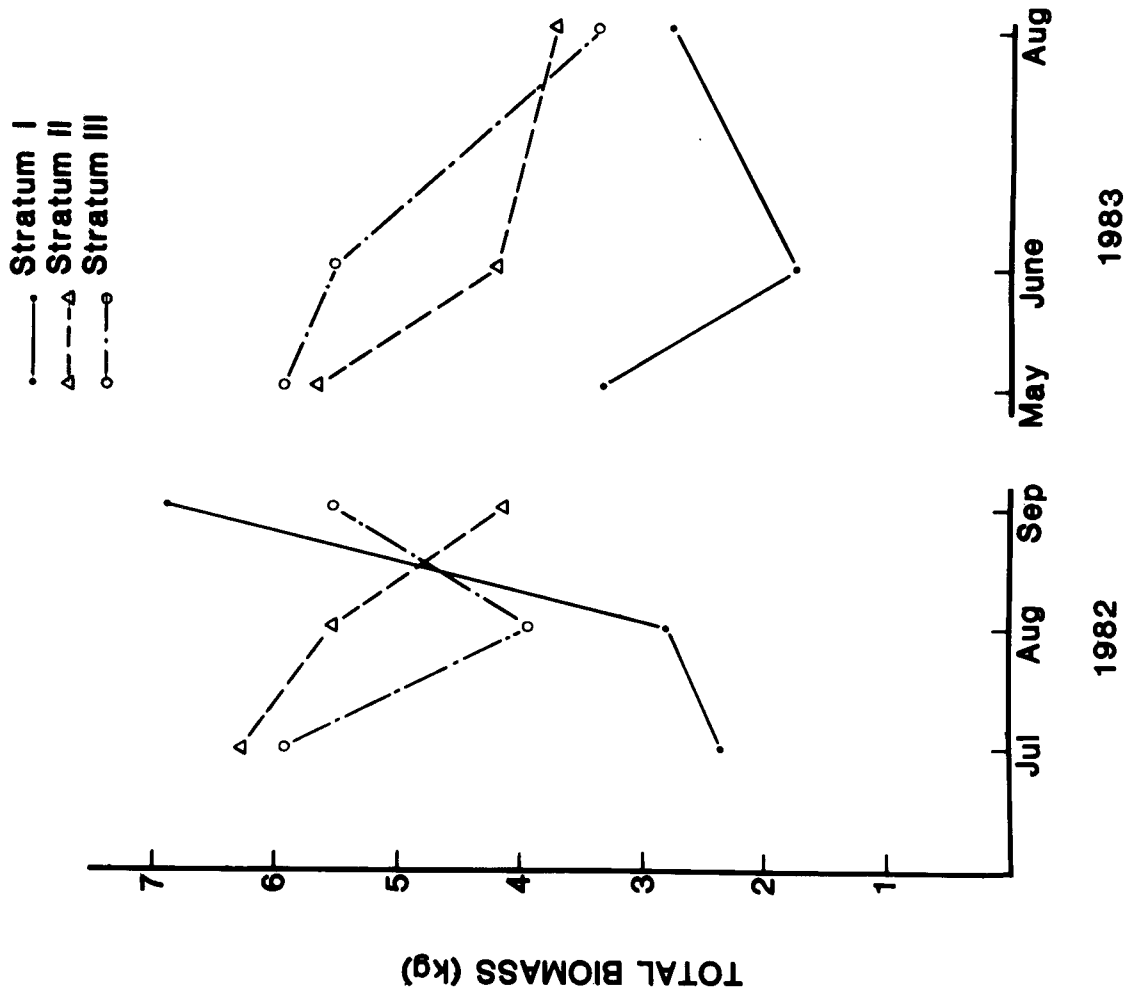
Figure 9. Total biomass of fish collected from each stratum during each survey conducted in the summers of 1982 and 1983. Each point is based on the combined catch from the otter trawl and surface trawl at 16 randomly selected locations within each stratum.

Table 9. Analysis of variance of biomass of fish (all species combined) taken during six surveys conducted during the summers of 1982 and 1983.

SOURCE	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
Survey	5	128353	1.28	0.2707
Strata	2	342722	3.43	0.0338
Stratum II vs III	1	1,800	0.02	-
Stratum I vs others	1	683,644	6.84	-
Interaction	10	110326	1.10	0.3590
Error	270	99918		
Levene's test for equal variances	17,270		3.49	0.0000
One-way analysis of variance test statistics for within-group variances not assumed to be equal				
Welch	17,100		2.73	0.0010
Brown-Forsythe	17,116		1.43	0.1346

Table 10. Total biomass (grams wet weight) of fish collected from each
          strata during each of the wet-season surveys.

	Strata I Biomass	Strata II Biomass	Strata III Biomass
July 82	2354	6297	5917
August 82	2839	5566	3960
Sept. 82	6895	4180	5519
YEAR TOTAL	12088	16043	15396
May 83	3372	5698	5949
June 83	1778	4214	5530
August 83	2814	3724	3392
YEAR TOTAL	7964	13636	14871

August 1982 but highest for the stratum in September 1982, when silver perch, B. chrysoura, and menhaden, B. smithi, accounted for a major portion of the fish biomass in Faka Union Bay.

The variation in biomass among trawl samples within a given stratum and survey was high, and this variation renders suspect conclusions we might draw from simple inspection of the biomass totals in Table 10 and Fig. 9. On the other hand the ANOVA does indicate that differences in overall biomass among the three strata were real. A partitioning of the sums of squares for the "Among Strata" source of variation (Table 9) reveals that essentially all the variation rests in the difference between Stratum I (Faka Union Bay) and the other two strata; i.e., Stratum II and Stratum III provided nearly identical total weights of fish for the study (29,679 and 30,267 g, respectively) whereas that for Stratum I was less by 30% (20,051).

Average fish size was also examined. Change in average fish size could reflect not only growth but also immigration, emigration and change in species composition. This variable is simply the ratio of the two variables previously analyzed by ANOVA, i.e., total biomass/total numbers. Thus, we must point out the redundancy and lack of independence between the analysis to follow and those discussed previously. Nevertheless, the variation in average body weight from stratum to stratum shows an interesting pattern over time (Fig. 10). In particular: (1) average size consistently increased or decreased over time in all three strata; (2) average fish size was consistently largest in Faka Union Bay;' and (3) within a given year, the ranks of the three strata according to size remained unchanged (although average fish sizes were very similar among the three strata in August 1982 and May 1983). The capture of a single large gafftopsail catfish (Bagre marinus) in Stratum I in August 1983 had a substantial influence on average fish size for that stratum and month.
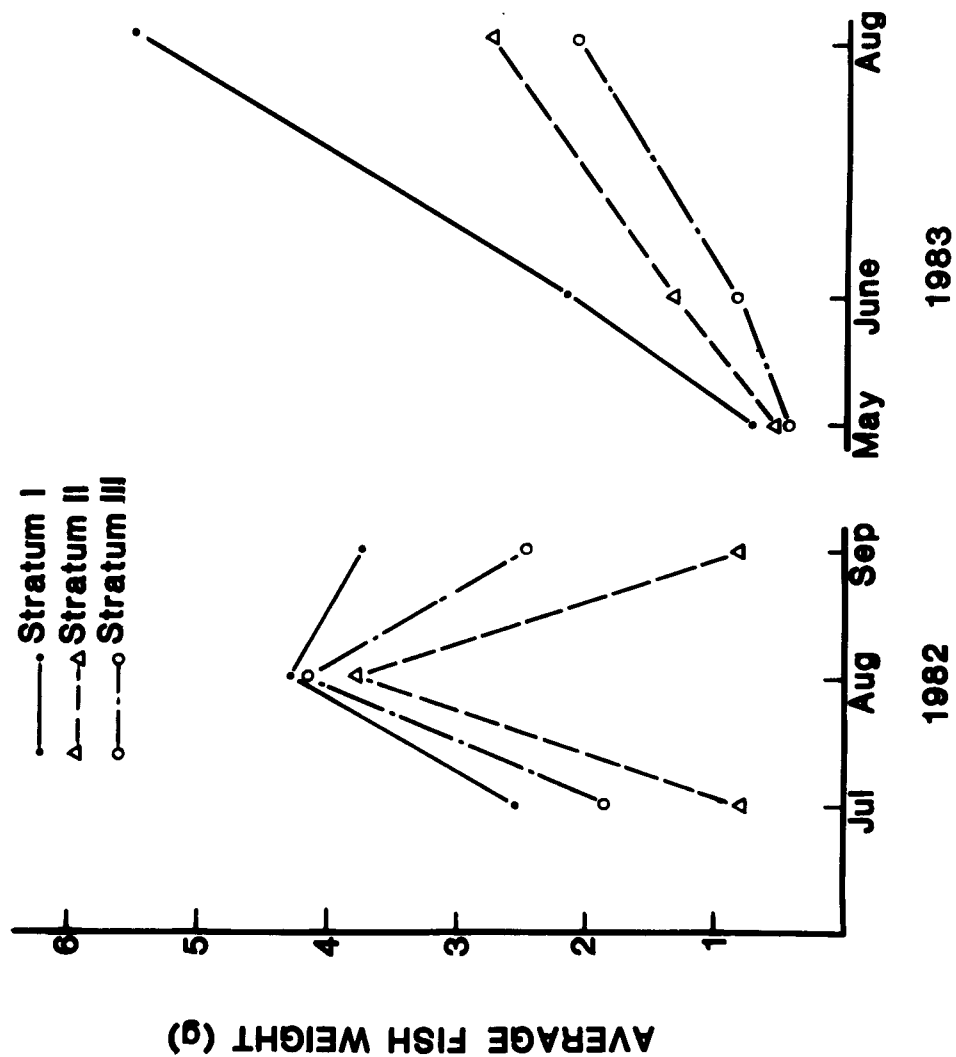
Figure 10. Average fish weight (biomass/number) collected from each stratum during each survey conducted in the summers of 1982 and 1983. Each point is based on the combined catch from the otter trawl and surface trawl at 16 randomly selected locations within each stratum.

Distribution of Fish by Sediment Type: Sediments were classified as mud and sandy-mud based on composition on the upper 5 cm. Mud was arbitrarily chosen as having a silt-clay content exceeding 40%, while sandy-mud was a sediment with $\leq$ 40% silt-clay. Of the 336 pairs of tows taken (all seven surveys), 91 were classified as having been taken over mud bottom while 245 were over sandy-mud (Table 11). Fewer fish per trawl were collected over sandy-mud (204) relative to mud (299) substrates. The majority of species were collected more frequently over sediments classified as sandy-mud. However, several species showed either little preference (i.e., similar numbers over either sediment category) or displayed a preference for mud sediments. Of those species where at least 50 individuals were collected during the study, blackcheeked tonguefish (S. plagiusa), lined sole (Achirus lineatus), and Atlantic thread herring (Opisthonema oglinum) were collected in similar numbers over both sediments. Those species displaying a preference for mud (> 40% silt-clay) included sand seatrout (Cynoscion arenarius), Atlantic bumper (Chloroscombrus chrysurus), sea catfish (Arius felis), gaffstopsail catfish (Bagre marinus), and white mullet (Mugil curema).

Distribution of Fish by Benthic Habitat Type: Each time the otter trawl was used to collect fish, the relative amount of shell or plant materials in the trawl at the end of the tow was recorded on an ordinal scale (none, very little, a moderate amount, and a lot). The same individual made all of these qualitative judgements on each survey, insuring a degree of uniformity among these categories. Thus, a "moderate amount" of algae at one station would approximate "a moderate amount" at any other station.

The majority of trawls occurred over bare substrates or substrates dominated by algae. Of the 336 paired trawls taken during the seven

Table 11. Total and average number and biomass of fish collected during seven
surveys in relation to relative amounts of shell and plant materials
recovered from the trawl. Also shown are numbers and biomass of fish
as a function of sand and mud; sand substrates were arbitrarily con-
sidered sediments having $\leq$ 40% silt-clay. N = number of observations.

Trawl Contents/Substrate	N	No. Fish		Wt. Fish (g)	
		Total	Mean	Total	Mean
Shell					
none	95	18,911	199	22,254	234
very little	155	36,134	233	38,168	246
moderate	74	19,852	268	20,920	283
a lot	12	2,431	203	3,955	329
Algae					
none	73	11,402	156	14,032	192
very little	93	16,275	175	20,900	225
moderate	70	12,793	183	15,326	219
a lot	100	36,858	366	35,039	350
Seagrass					
none	265	58,791	222	65,720	248
very little	60	14,462	241	14,132	235
moderate	6	2,211	368	3,324	554
a lot	5	1,864	373	2,122	424
Detritus					
none	109	27,676	254	26,763	245
very little	189	41,114	217	51,618	273
moderate	22	4,165	189	3,300	150
a lot	16	4,373	273	3,616	226
Sediment					
mud	91	27,240	299	31,359	345
sandy-mud	245	50,088	204	53,939	220

surveys, 74% contained little or no shell; 49% contained little or no algae;
and 97% contained little or no seagrass (Table 11). The shell collected
normally consisted of oyster shell and the algae were dominated by
Rhizoclonium hookeri and Gracilaria spp. Seagrass was primarily Halophila
engelmanni or Hadodule wrightii and only occasionally were Thalassia blades
brought up in our trawls. The general absence of seagrass from our trawls
was surprising, particularly considering the geographic coverage of our
sampling stations. Carter et al. (1973) reported densities up to 250 g dw/m^2 in
Fakahatchee Bay and 20-30 g dw/m^2 in Faka Union Bay in July and September 1972.
While our sampling method was not designed to sample seagrasses, our experience
has shown that trawling does remove seagrasses from bottom sediments,
particularly soft sediments such as those characteristic of the Ten Thousand
Island area. Based on the geographic extent of our benthic core analysis (these
also did not show seagrasses) and otter trawls, we conclude that seagrasses are
not currently a significant or dominant vegetation type in this system of
shallow bays.

Average density and average fish size increased with increasing
amounts of algae or seagrass (Table 11). Average fish size also showed a
positive relationship with the amount of shell encountered in the trawl, but
neither density nor size varied consistently with detritus. On bottoms where
seagrasses were prevalent ($\geq$ moderate categories) and where the maximum
density of algae occurred, an average of 369 fish per trawl were collected
while only 216 fish per trawl were collected elsewhere. Seagrass and algal
areas, however, were only a relatively small portion of the total substrate
sampled in our study, 3.3% and 30%, respectively. To the extent that shell,
algae, or seagrass in the trawl reduced tow speed and gear efficiency, then we

have underestimated average fish sizes and densities at higher levels of shell, algae, and seagrasses.

Non-pelagic species made up only a small fraction of the fish collected over either shell, algal, or seagrass areas, and several species were among the dominants in all of these habitat types (Table 12). Of the more than 49,000 fish collected over algal areas, 83% were pelagic species: $A.$ mitchilli, $A.$ hepsetus, $B.$ smithi, and $M.$ martinica. These species feed primarily in the water column and should be less effected by bottom type than other species. The benthic species present were dominated by silver perch ($B.$ chrysoura), pinfish ($L.$ rhomboides) and silver jenny ($E.$ gula), which together accounted for 5,368 individuals or 63% of the remaining fish collected over predominantly algal bottoms. Shell samples also were dominated by the same four pelagic species, representing 86% of the 22,283 individuals collected within moderate to heavy shell areas. The same three dominant benthic species present over algal bottoms also were prevalent over shell bottoms, where they made up 50% of the remaining 3,171 individuals collected. Sea catfish ($A.$ felis) were among the dominants, and were collected in similar numbers in both shell and algal areas (Table 12); these habitats apparently occurred in muddy areas. Where seagrasses were collected, $A.$ mitchilli and $M.$ martinica were the only pelagic species to predominant, together contributing 82% of the 4,075 individuals collected. Silver perch, silver jenny, blackcheeked tonguefish ($S.$ plagiusa), and pinfish represented 61% of the remaining 734 individuals collected in seagrass areas.

Because fish size and/or density increased with the amount of shell, algae, and grass found in the trawl, we examined the frequency of occurrence of habitat types in the three strata (Table 13). One can use the table to assess the extent to which differences in fish density among strata are due to differences in the frequencies of habitat types therein

Table 12. List of the dominant fishes collected at sites where shell, algae and seagrass were present in moderate or high abundance. The species are ranked in decreasing order of abundance. Numbers in parentheses represent numbers of individuals collected.

Shell (22,283)	Algae (49,651)	Seagrass (4,075)
A. mitchilli (9661)	A. mitchilli (22,688)	A. mitchilli (3173)
B. smithi (3622)	A. hepsetus (7282)	B. chrysoura (230)
M. martinica (2984)	B. smithi (6246)	M. martinica (169)
A. hepsetus (2845)	M. martinica (4917)	E. gula (77)
B. chrysoura (668)	B. chrysoura (2459)	S. plaguisa (73)
L. rhomboides (619)	L. rhomboides (1963)	L. rhomboides (70)
E. gula (317)	E. gula (946)	A. hepsetus (67)
A. felis (233)	O. chrysoptera (367)	O. chrysoptera (38)
O. chrysophera (210)	S. scovelli (311)	E. argenteus (19)
S. plagiusa (115)	A. felis (266)	S. scovelli (18)

Table 13. Frequencies of occurrence and average densities of fish in habitats classified by the amounts of shell, algae and seagrass contained in our trawls. S = shell, A = algae and G = seagrass. Subscripts: 0 = none, 1 = small amount, 2 = moderate amount, 3 = a large amount. Substrates not encountered are omitted for conciseness.

Substrate Type	Stratum I		Stratum II		Stratum III	
	n	Average density	n	Average density	n	Average density
$S_0A_0G_0$	6	93	7	114	17	140
$S_0A_0G_1$			3	437		
$A_0A_1G_0$	9	37	7	434	2	146
$S_0A_1G_1$	1	38	7	404		
$S_0A_2G_0$	9	124			8	220
$S_0A_2G_1$	3	52				
$S_0A_2G_2$			1	777		
$S_0A_3G_0$	3	31	3	318	7	164
$S_0A_3G_3$			2	668		
$S_1A_0G_0$	7	75	2	376	14	90
$S_1A_1G_0$	21	43	9	30	13	332
$S_1A_1G_1$			9	228	2	317
$S_1A_1G_2$			1	78		
$S_1A_2G_0$	15	121	4	195	7	288
$S_1A_2G_1$	2	32	4	93		
$S_1A_2G_2$	1	17	2	126		
$S_1A_3G_0$	9	283	6	535	15	613
$S_1A_3G_1$			9	312	2	594
$S_1A_3G_2$			1	1088		
$S_2A_0G_0$	4	13	1	32	7	476
$S_2A_0G_1$					1	1
$S_2A_1G_0$	2	24	2	66	3	90
$S_2A_1G_1$	1	34				
$S_2A_2G_0$	7	138	2	997	1	185
$S_2A_2G_1$			2	104	1	32
$S_2A_3G_0$	8	175	13	395	6	592
$S_2A_3G_1$	1	36	7	180	2	327
$S_2A_3G_3$	1	66	2	232		
$S_3A_0G_0$			1	1	2	197
$S_3A_0G_1$	1	1				
$S_3A_1G_0$					2	120
$S_3A_1G_1$			2	392		
$S_3A_2G_0$	1	282				
$S_3A_3G_0$			3	243		

encountered during the surveys. In addition, the table permits an examination of the consistency of fish density within a given habitat type across the three strata; i.e., one can, for the 12 habitats that occurred in all three strata, compare fish densities so that the strata comparisons of fish density are not confounded by differences in habitat. The reader should also note that because sampling sites within strata were selected at random, the frequencies of occurrence of the different habitat classes within a given stratum in Table 13 provide estimates of the relative proportions of each habitat type within that stratum. The highest average density was observed in Stratum II and was for a single trawl sample in a habitat defined by little shell (S_1), a moderate amount of seagrass (G_2), and a large amount of algae (A_3). The frequency of samples containing moderate or large amounts of shell and algae and none or low amounts of seagrass was as high in Stratum II as for the other two strata combined. Nine of the 11 samples containing moderate or large amounts of seagrass also occurred within Stratum II.

The most striking revelation of the analysis, however, is the consistency with which relative densities within a given habitat type are lowest in Stratum I. In 11 of the 12 available comparisons among all three strata, Faka Union Bay had the lowest fish densities, and this was also the case in all of the five available comparisons of Faka Union Bay and a single one of the other two strata. We conclude, therefore, that differences among strata in overall fish densities cannot simply be attributed to probable differences in the availability of certain "preferred" substrates. Some other factor must be responsible for Faka Union Bay's lower fish densities.

Fish-salinity relationships: Because this study was predicated on possible future modifications of the freshwater inflow to Faka Union Bay and the need for information on likely resulting impacts on the fish community within the bay, it is desirable to examine the abundance of different species in waters differing in salinity. Since this study involved sampling natural populations rather than measuring the role of salinity in behavioral and physiological experiments, the evidence provided by these data is, of course, correlative in nature. Because many (or most) of the species of fishes have well-defined recruitment to estuarine nursery areas, and because rainfall exhibits a regular seasonal pattern as well, observed relationships between a species' abundance and salinity obviously may reflect correlation among temporal phenomena rather than inherent salinity tolerance or preference of the species of fish. Thus, we come up against the inherent limitations of evidence obtained from surveys rather than controlled experimentation. However, in the absence of data from controlled experiments that would in any case fail to include the multiplicity of factors that determine distribution of fishes in time and space, we believe the data gained from the surveys should be carefully examined. In the discussion to follow we compare salinities and relative fish densities measured in 1982 with those measured in 1983, but we remind the reader that because the timing of surveys was different for the two years, comparisons between years are of less interest and validity than comparisons among the three strata. We first present information on the percent occurrence of fishes in different salinity classes; i.e., the percentage of trawl samples in which the species was collected that fell within a specified salinity interval. We then examine the numerical abundance in relation to salinity for about 30 species that were taken with sufficient frequency to provide a clear picture of their distribution along the salinity gradient.

We subdivided the salinity scale into 12 mutually exclusive salinity classes, each class having a width of 3 ppt. The percentage occurrence of each species was then computed (Table 14). Species collected on fewer than six occasions were not considered to provide sufficient information for drawing conclusions about their distributions along the salinity gradients. These species were collected either at high or low salinity and generally not at intermediate salinities. Forty-three species were collected on more than five occasions, and for each of these species the average and standard deviation of salinity for the waters from which they were collected were calculated. Each species is ordinated with respect to these two statistics in Figure 11. In this figure the position of the species with respect to the horizontal axis indicates the mean salinity of waters from which one or more individuals of the species were collected. It is then an estimate of that species' salinity preference. Its position with respect to the vertical axis indicates the degree to which that species is narrow (stenohaline) or broad (euryhaline) in its distribution along the salinity gradient. For example, hogchoker (Trinectes maculatus, No. 32), Atlantic needlefish (Strongylura marina, No. 23), gulf kingfish (Menticirrhus littoralis, No. 18) and the scaled sardine (Harengula pensacolae, No. 28) were encountered more frequently and consistently in waters of lower salinity than other species. Conversely, striped burrfish (Chilomycterus schoepfi, No. 64), chain pipefish (Syngnathus louisianae, No. 37) and the southern puffer (Sphoeroides nephelus, No. 47) were encountered only in waters of higher salinity. The remaining species tended to be found over a broad range of salinity. Eleven species, in fact, were collected from waters of all 12 of the salinity classes.

Table 14 The percentage occurrence of fish species in relation to salinity class.
SC1 = 0.0-2.9 ppt, SC2 = 3.0-5.9 ppt, etc.

| Species Code	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11	SC12	Number of collections
1	0.9	3.7	10.1	7.8	10.6	14.7	8.3	5.5	5.5	17.4	11.0	4.6	218
2	1.1	4.3	7.4	8.5	9.0	10.6	8.0	6.9	5.3	20.7	12.8	5.3	188
4	2.5	8.5	14.4	13.6	7.6	12.7	6.8	5.9	1.7	11.9	8.5	5.9	118
5	0.5	4.2	9.7	13.9	11.6	15.7	10.2	6.9	5.1	10.2	7.4	4.6	216
6	2.0	7.8	12.7	15.7	15.7	15.7	11.8	5.9	2.9	3.9	3.9	2.0	102
7	0	0	10.7	21.4	21.4	25.0	3.6	7.1	3.6	3.6	3.6	0	28
8	0.9	4.4	12.3	11.4	14.9	14.0	13.2	8.8	3.5	7.9	6.1	2.6	114
9	0	0	10.0	6.7	13.3	23.3	23.3	3.3	3.3	13.3	3.3	0	30
10	0.8	3.0	9.8	11.4	11.4	13.6	7.6	6.1	4.5	20.5	6.8	4.5	132
11	0.9	0.9	6.5	10.2	7.4	13.9	7.4	2.8	3.7	24.1	15.7	6.5	108
12	0	0	3.0	9.1	9.1	6.1	15.2	0	3.0	30.3	12.1	12.1	33
13	0	0	0	1.5	4.6	7.7	7.7	1.5	4.6	43.1	20.0	9.2	65
14	0	0	0.9	8.0	3.6	17.0	10.7	8.0	7.1	25.9	12.5	6.3	112
15	0	4.7	9.3	4.7	9.3	9.3	9.3	4.7	9.3	11.6	18.6	9.3	43
16	0	0	0	13.6	27.3	27.3	13.6	4.5	4.5	0	9.1	0	22
17	4.2	4.2	0	8.3	8.3	16.7	8.3	8.3	8.3	12.5	16.7	4.2	24
18	0	6.3	31.3	6.3	31.3	6.3	12.5	0	0	6.3	0	0	16
19	0	8.3	8.3	25.0	16.7	4.2	4.2	8.3	0	20.8	4.2	0	24
20	0	20.0	20.0	0	0	0	0	0	0	0	0	60.0	5
21	0	0.7	5.0	6.5	6.5	13.7	10.1	6.5	5.0	21.6	17.3	7.2	139
22	0	0	0	4.3	0	0	4.3	0	4.3	21.7	30.4	34.8	23
23	0	14.3	14.3	0	28.6	42.9	0	0	0	0	0	0	7
24	0	0	1.7	1.7	5.0	16.7	15.0	8.3	6.7	25.0	16.7	3.3	60
25	0	0	1.7	1.7	5.0	16.7	15.0	8.3	6.7	25.0	16.7	3.3	60
26	0	2.5	10.0	7.5	2.5	7.5	2.5	7.5	7.5	20.0	10.0	22.5	40
28	0	4.8	28.6	9.5	14.3	14.3	19.0	4.8	4.8	0	0	0	21
29	0	3.0	15.2	12.1	12.1	9.1	9.1	15.2	3.0	15.2	3.0	3.0	33
30	0	5.3	5.3	10.5	31.6	21.1	5.3	10.5	5.3	5.3	0	0	19
31	0	0	0	0	100.0	0	0	0	0	0	0	0	1
32	16.7	0	16.7	50.0	16.7	0	0	0	0	0	0	0	6
33	0	0	3.2	9.7	8.1	16.1	8.1	3.2	3.2	29.0	16.1	3.2	62
34	0	0	0	0	33.3	33.3	33.3	0	0	0	0	0	3
35	0	0	0	100.0	0	0	0	0	0	0	0	0	2
37	0	0	0	0	0	0	9.1	0	9.1	45.5	18.2	18.2	11
38	1.3	2.5	11.3	8.8	8.8	12.5	6.3	11.3	2.5	18.8	11.3	5.0	80
39	0	0	0	0	50.0	50.0	0	0	0	0	0	0	2
40	0	0	0	0	0	18.2	18.2	0	9.1	45.5	9.1	0	11
41	2.0	0	3.9	7.8	7.8	17.6	11.8	2.0	0	31.4	9.8	5.9	51
42	0	0	25.0	0	0	50.0	0	25.0	0	0	0	0	4
43	0	0	100.0	0	0	0	0	0	0	0	0	0	1
44	0	0	0	0	0	0	20.0	20.0	0	0	0	60.0	5
45	0	0	0	0	0	0	0	0	0	100.0	0	0	1
46	0	1.3	10.3	6.4	1.3	12.8	5.1	7.7	3.8	26.9	15.4	9.0	78
47	0	0	0	0	0	7.1	0	0	0	57.1	35.7	0	14
48	0	0	22.2	0	0	22.2	11.1	11.1	11.1	11.1	11.1	0	9
49	0	0	0	33.3	0	0	0	0	16.7	50.0	0	0	6
50	0	0	8.3	25.0	0	8.3	16.7	16.7	0	8.3	16.7	0	12
51	0	0	10.0	0	0	20.0	10.0	0	10.0	20.0	30.0	0	10
52	0	66.7	0	0	0	0	0	0	0	33.0	0	0	3
53	0	0	0	0	0	12.5	6.3	6.3	6.3	43.8	12.5	12.5	16
54	0	0	25.0	0	0	25.0	0	0	0	50.0	0	0	4
55	0	0	0	10.0	10.0	10.0	10.0	20.0	20.0	0	20.0	0	10
57	0	0	0	0	0	0	0	0	0	0	33.3	66.7	3
59	0	0	0	28.6	14.3	28.6	14.3	0	0	14.3	0	0	7
62	0	0	0	0	0	0	0	0	0	0	100.0	0	1
63	0	0	0	0	0	0	0	0	0	100.0	0	0	1
64	0	0	0	0	0	0	11.1	0	11.1	66.7	11.1	0	9
65	0	0	0	0	0	0	0	0	0	100.0	0	0	1
66	0	0	0	0	0	0	0	0	0	0	50.0	50.0	2
67	0	0	0	0	0	0	0	0	0	0	100.0	0	1
68	0	0	0	0	0	0	0	0	0	0	0	100.0	1
69	0	0	0	0	0	0	0	0	0	0	0	100.0	1
70	0	0	0	0	0	0	0	0	0	0	100.0	0	2
71	0	0	0	50.0	0	0	0	0	50.0	0	0	0	2
72	0	0	0	0	0	0	0	0	0	100.0	0	0	1
73	0	0	0	0	0	0	0	0	0	100.0	0	0	4
74	0	0	0	0	0	0	0	0	0	100.0	0	0	1
75	0	0	0	100.0	0	0	0	0	0	0	0	0	1
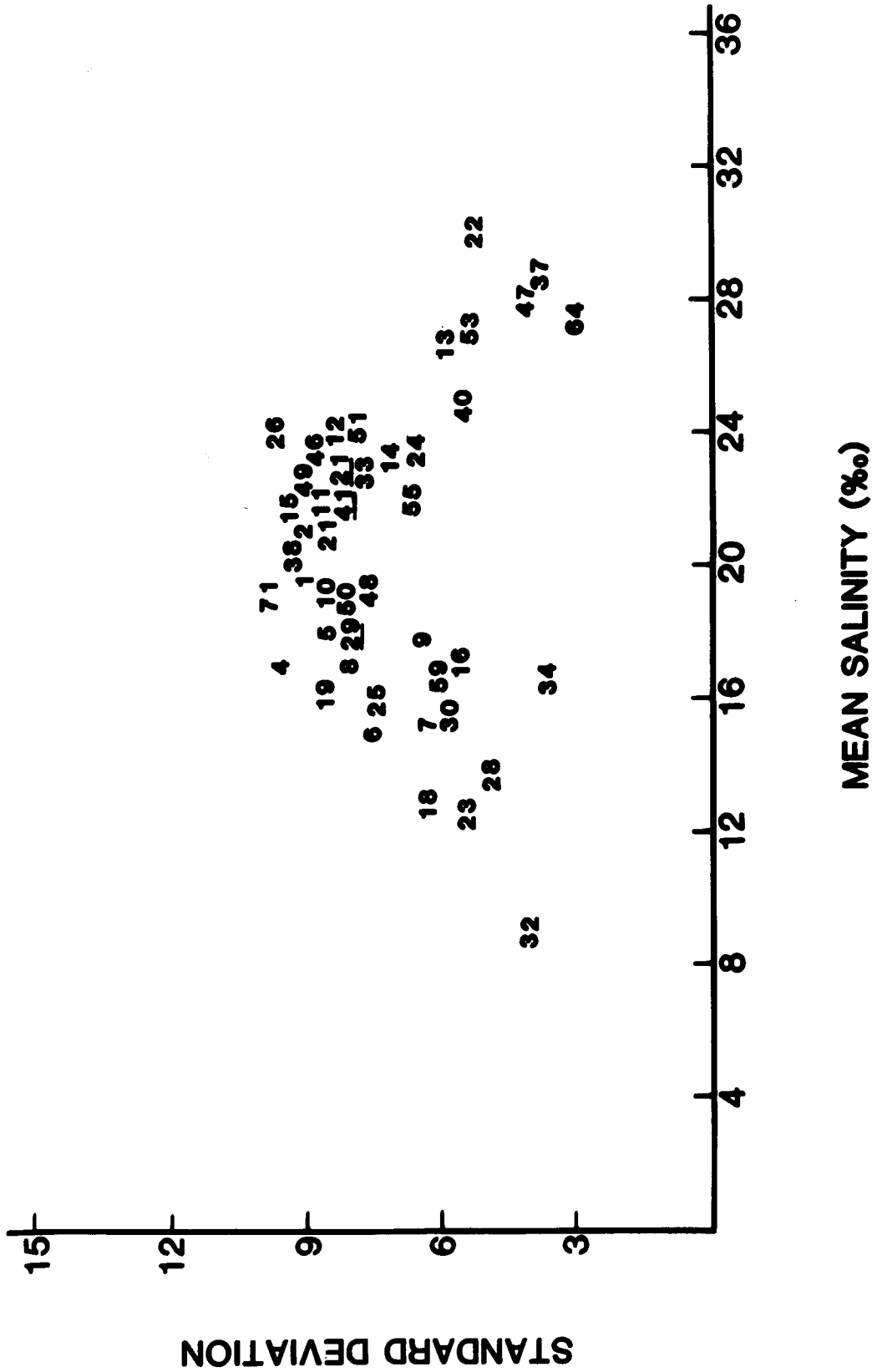
Figure 11. Ordination of fish species with respect to the mean salinity and standard deviation of salinity of the waters from which they were collected. The means and standard deviations were computed on the basis of occurrence of a species in a sample and therefore mean salinity is the average salinity of water from which at least one specimen of that species was collected.

The number of fish samples taken within each salinity class changed markedly from 1982 to 1983 in accordance with the overall changes in salinity from one wet season to the next. However, for the two years combined there was a rather even distribution of samples among the salinity classes (Table 15).

Another way to examine the distributions of fish along the salinity gradient of the estuary is to take into account the number of individuals collected at each salinity rather than the number of collections in which the species occurred. We computed the mean and standard deviation of salinity in that way for each of the 41 species for which at least ten individuals had been collected (Fig. 12). This approach produced a somewhat different ordination of species than the previous method. For example, the sea catfish (Arius felis, No. 29) now has a mean salinity of 8.4 ^{O}/oo (Fig. 12) whereas the estimate based upon occurrence was 17.8 ^{O}/oo (Fig. 11). This results from the fact that the greatest numbers of individuals of this species were collected at a salinity of about 6 ^{O}/oo, even though individual fish were collected over most of the entire salinity gradient. Other species that occurred in larger numbers at low to intermediate salinities (Fig. 12) included silver jenny (Eucinostomus gula, No. 5), spotfin mojarra (E. argenteus, No. 4), and blackcheeked tonguefish (Symphurus plagiusa, No. 6). At the other end of the salinity scale, yellowfin menhaden (Brevoortia smithi, No. 26) had the highest mean salinity. This species also was collected over a rather broad band of salinity but the greatest numbers were collected at approximately 26 and 34 ^{O}/oo. Among the other species that occurred in generally higher abundances at intermediate to high salinities included pigfish (Orthopristis chrysoptera, No. 13), gulf pipefish

Table 15. Numbers of fish samples collected in each of the 12 salinity classes.

| Survey	Stratum	1.5	4.5	7.5	10.5	13.5	16.5	19.5	22.5	25.5	28.5	31.5	34.5
						Salinity Class Midpoint °/oo							
July 1982	I	2	2	8	4								
	II				2	7	7						
	III		1	1	3	4	5	0	1				
August 1982	I	1	7	7	1								
	II			2	11	3							
	III				1	4	9	0	2				
September 1982	I	1	1	7	2	5							
	II					2	3	8	3				
						2	2	1	6	5			
1982 overall		4	11	25	22	26	25	14	11	6	0	0	0
May 1983	I									3	10	3	
	II										11	5	
	III											6	10
June 1983	I					1	4	5	6				
	II									4	12		
	III											6	10
August 1983	I			1	9	2	4						
	II					1	9	6					
	III						2	4	7	2	1		
1983 overall				1	9	4	19	15	13	9	40	24	10
TOTAL		4	11	26	31	30	44	29	24	15	40	24	10
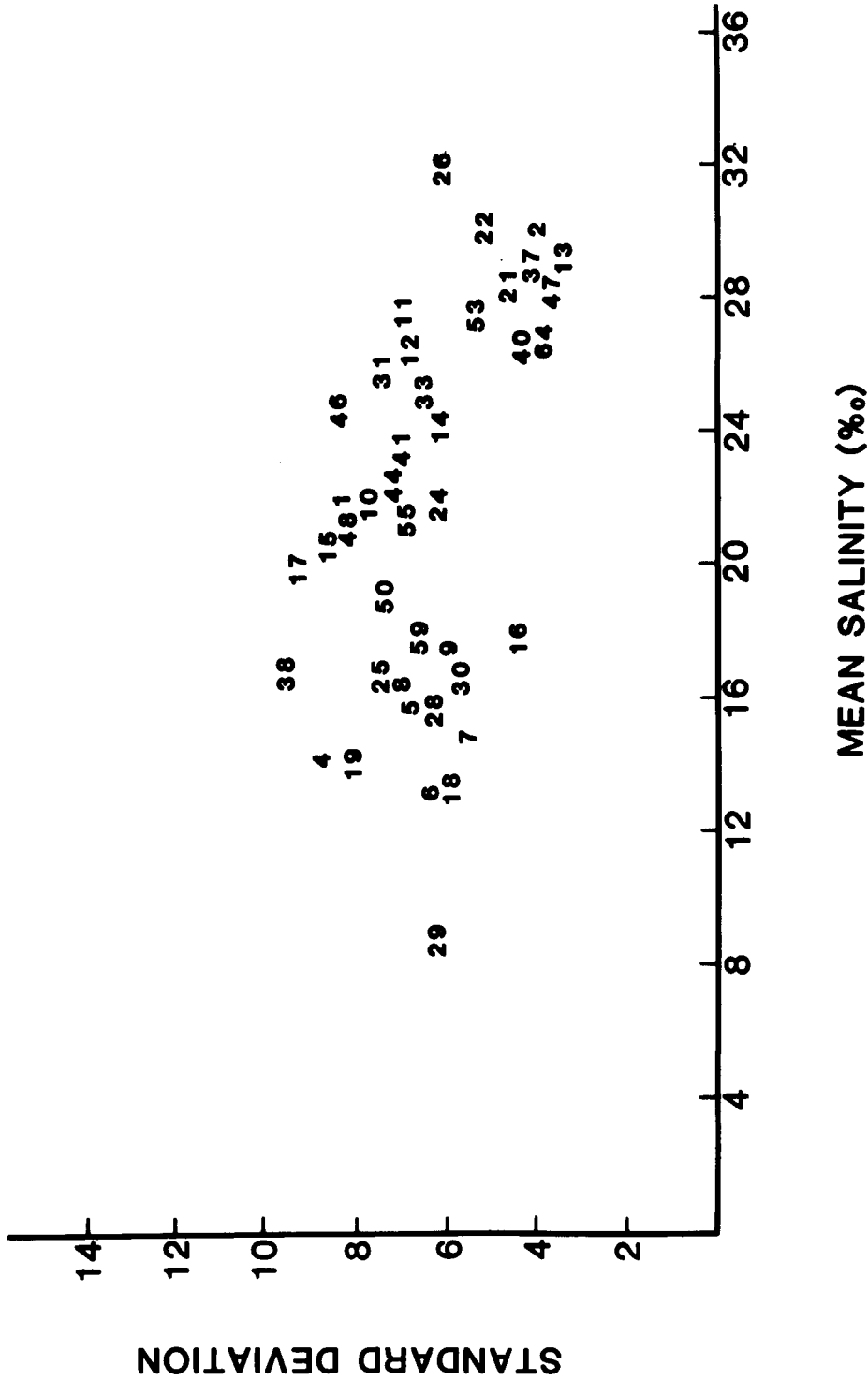
Figure 12. Ordination of fish species with respect to the mean and standard deviation of salinity of the waters from which they were collected. The mean and standard deviations were computed on the basis of numerical abundance of a species in a sample and therefore mean salinity is the average salinity for all the individual specimens of that species.

(Syngnathus scovelli, No. 33), striped anchovy (Anchoa hepsetus, No. 2),
silver perch (Bairdiella chrysoura, No. 10), and pinfish (Lagodon
rhomboides, No. 11).

The actual distributions of three species, selected to illustrate
types of distributional patterns encountered, are presented in Figs. 13 to
15. The first is for bay anchovy (Anchoa mitchilli). It was encountered in
appreciable numbers over virtually the entire range of salinity. The second
is for pigfish (Orthopristis chrysoptera). This species was encountered over
a broad range of salinity but was much more abundant in the interval from
28-24 °/oo than elsewhere. The last figure depicts the distribution of the
spotfin mojarra (Eucinostomus argenteus). This species, while taken over the
entire salinity gradient, was much more abundant over the broad interval from
2-20 °/oo.

Regardless of whether occurrence or numerical abundance is used
to compute the mean and standard deviation of salinity for a species, the
general pattern of the ordinated species is similar, i.e., the mean salinities
for the species are fairly evenly spread between 12 and 30 °/oo and the standard
deviations range from about 3 to 10. The ordinations provide a basis for
predicting which species may become more prevalent in Faka Union Bay during the
wet season in the future if average salinities rise as a result of a change in
water management. One would expect that the shift in numerical abundance of
fish species might be gradual and involve substantial time lags if salinity
exerts its influence on fish distribution indirectly through habitat-food
resources. On the other hand, if the lower standing crop and larger average
size of forage fishes in Faka Union Bay is primarily a consequence of greater
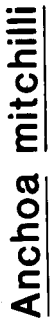abundance of oligohaline predators such as snook (Centropomus undecimalis) and

Figure 13. Abundance of the bay anchovy, Anchoa mitchilli, in relation to salinity. This species was collected in 218 of the 288 samples taken during the summers of 1982 and 1983.
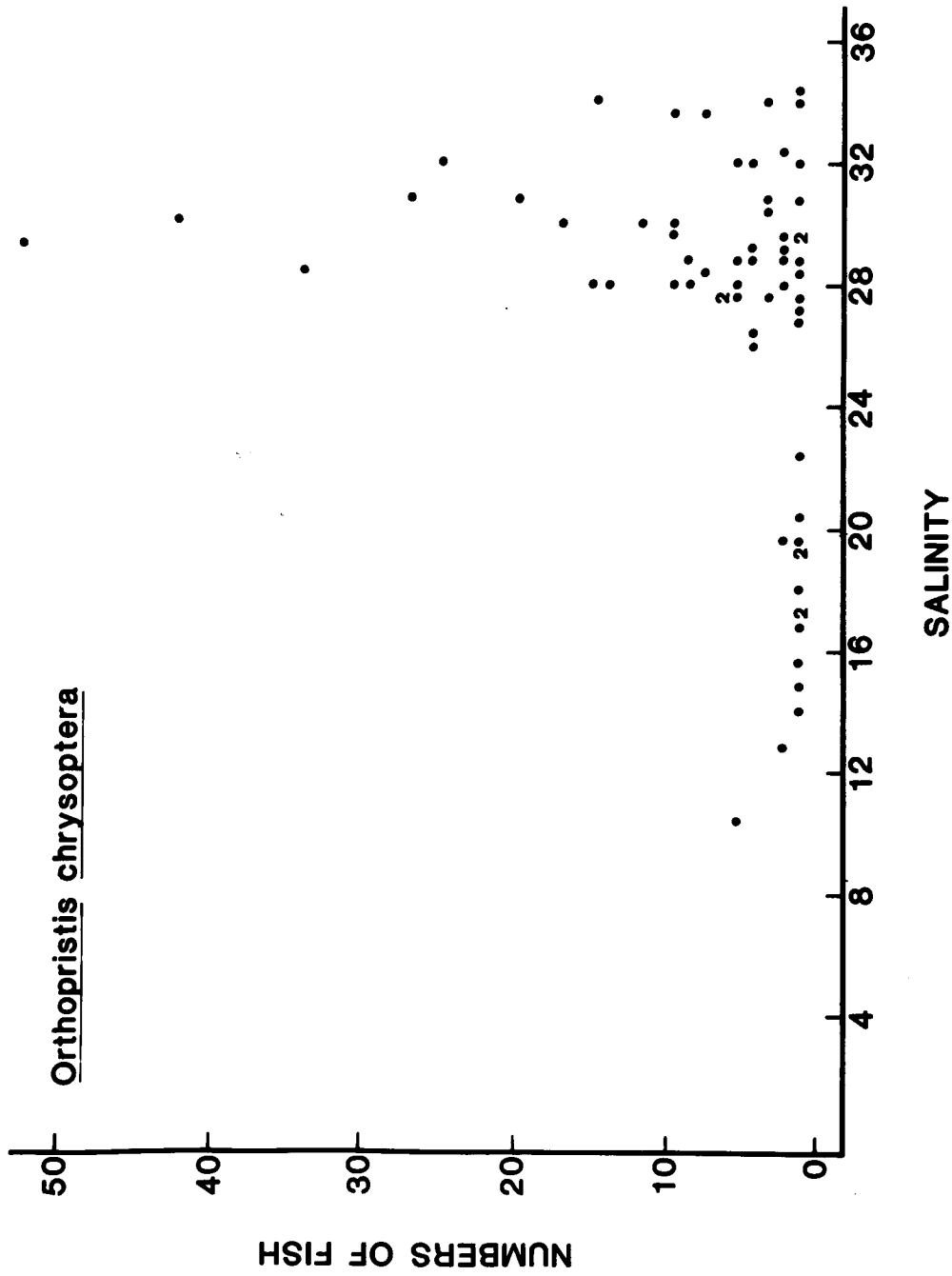
Figure 14. Abundance of the pigfish, Orthopristis chrysoptera, in relation to salinity. This species was collected in 65 of the 288 samples taken during the summers of 1982 and 1983.

66

Figure 15. Abundance of the spotfin mojarra, Eucinostomus argenteus, in relation to salinity. This species was collected in 118 of the 288 samples taken during the summers of 1982 and 1983.

tarpon (Megalops atlantica), then one would expect t:.. fish community response to freshwater inflow via Faka Union Canal to be more immediate. The fact that salinities within Faka Union Bay in May 1983 were very similar to those in the collateral bays to the east and west and yet fish densities remained much lower within Faka Union Bay implies that either salinity was not responsible for fish density variation or the response of the fish population lagged behind the change in salinity, suggesting that salinity may exert its effects indirectly. The distribution of fish over the range of availability salinities during the different salinity regimes extant during the summers of 1982 and 1983 suggests that relative salinity rather than absolute salinity may be important in determining fish densities in the different bays within the region.

Stomach Contents Analyses: Analyses of the contents of fish stomachs by strata (Fig. 16) showed that zooplankton, shrimp, amphipods, polychaetes, and fish were the principal dietary components throughout the entire study area on each sampling occasion (July, August, September 1982; May, June, August 1983). These data are based on analyses of gut contents of all species including anchovy. Plant detritus contributed less than 1% to the diets of the juvenile fishes sampled. Menhaden, a detritus-eating species in the late juvenile stage, were caught in large numbers only in lengths less than ca. 35 mm, a stage when they are plankton feeders. Live plants, primarily diatoms, contributed about 3% by weight to the diets. Faka Union Bay (Stratum I) fish stomachs contained more zooplankton, shrimp, isopods, and larval gastropods, about the same percentage of amphipods and cumaceans, and far less polychaetes than did fish collected from either Strata II and III. Fish collected from the eastern stations (Stratum II) had more polychaetes and less fish in their stomachs than did fish from the western stations (Stratum
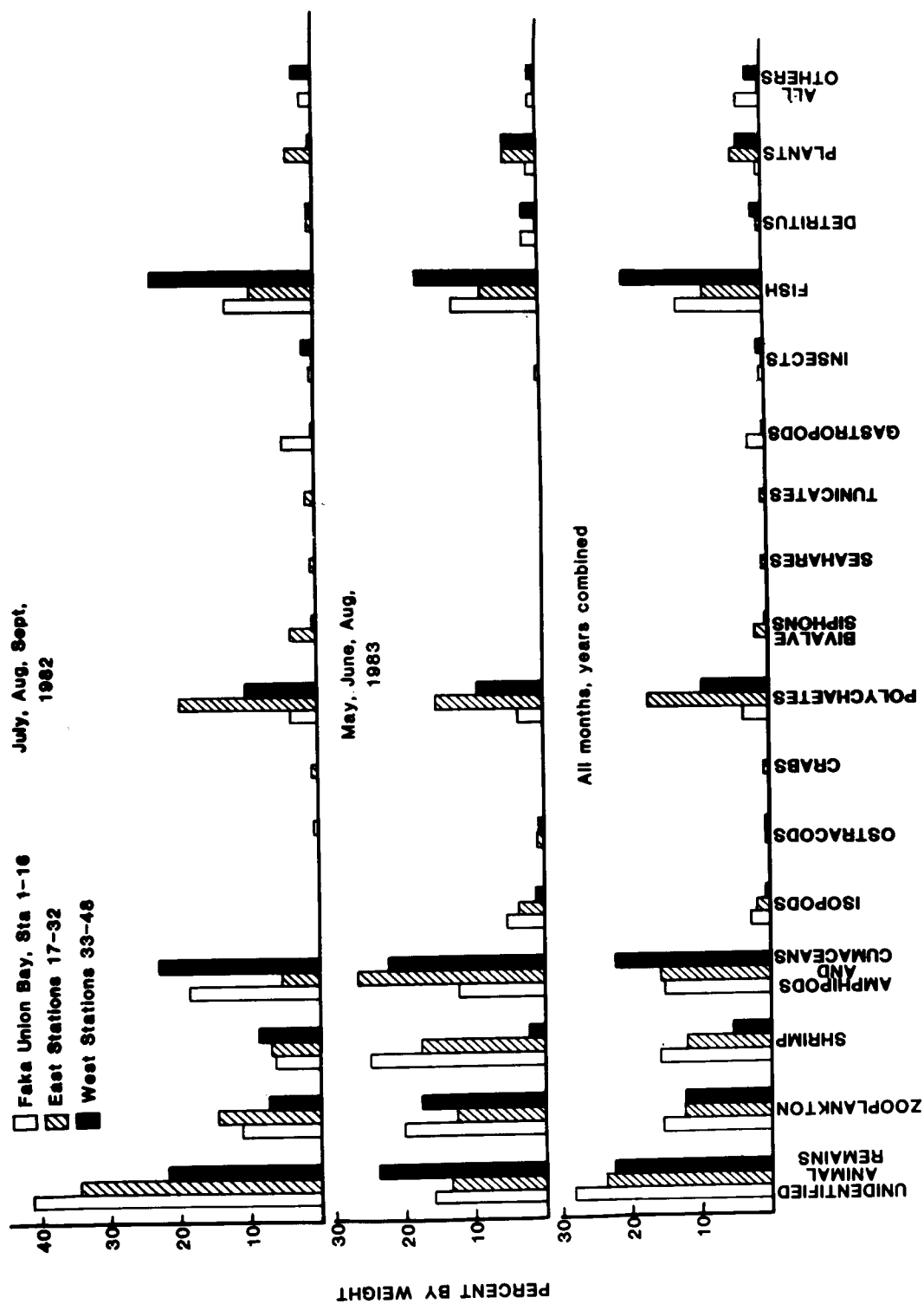
Figure 16. Comparison of stomach contents of fishes ≤ 100 mm from Strata I (Faka Union Bay stations, 1-16), Strata II (eastern stations, 17-32), and Strata III (western stations, 33-48). All fish species grouped together by year (top two panels) and average for combined years (bottom panel).

III). Crabs were present only in stomachs analyzed from Stratum II and they were absent from fish stomachs analyzed from Strata I and III. This observation is consistent with the higher relative abundance of crabs found in trawl catches from Strata II. Although shrimp (Penaeus and Palaemonetes) were relatively less abundant in almost every monthly trawl catch analysis (see Fig. 20) in Faka Union Bay, they were important in the diet of fish in Faka Union Bay and contributed 16% by weight to the stomach contents. This contrasts with an average of about 9% by weight for shrimp in stomachs of fishes from the bays on either side of Faka Union Bay.

A comparison of stomach contents of fishes collected in 1982 with fishes collected in 1983 showed that 1982 stomachs had about 32% by weight of unidentifiable animal remains (partially digested animal tissue), whereas in 1983, only about 17% of the stomach contents were unrecognizable. This is probably because only fishes collected before 1000 hrs were used in the 1983 stomach analysis to reduce bias due to faster digestion of softer prey. As a result, the average percentage of zooplankton, shrimp, and amphipods was greater in 1983; however, the percentage of other food types was about the same or even less. Some of the difference between years is possibly due to seasonal changes, in that the 1983 collections, which were an average of 1.5 months earlier in the summer than the 1982 collections, contained fish at an earlier developmental stage that had been feeding on seasonally available prey. When stomach contents from August 1982 and August 1983 are compared, however, considerable variation is found (differences of 100% or more) in more than one-half of the six major food categories listed in Table 16. This variation cannot be explained, but may be due to variation in the species composition of the fish subsamples processed for stomach content analysis for the two years, or it could be due to the fact

Table 16. Comparison of the percentages by weight of the major food components from the three strata from the August 1982 and the August 1983 fish community samples (fork length $\leq$ 100 mm). Asterisk indicates more than a two-fold difference between years. (UAR = unidentified animal remains.)

	Stratum I		Stratum II		Stratum III	
	'82	'83	'82	'83	'82	'83
UAR	24	9*	29	15	19	7*
Zooplankton	10	10	14	6*	7	8
Shrimp	4	46*	4	12*	20	6*
Amphipods	26	7*	3	5	17	9*
Polychaetes	5	8	29	38	18	15
Fish	28	12*	12	24*	13	51*

that only fish captured before 1000 hrs were used in 1983. Overall, the most consistent relation between 1982 and 1983 was that polychaetes, a major food item, were only about 30% as prevalent in stomachs of Faka Union Bay fishes compared to the other two strata.

One could conclude that the low relative weight of polychaetes in fish stomachs from Faka Union Bay may have been due in some way to reduced salinity; however, when stomach contents were analyzed by salinity groups, polychaetes were more abundant in stomachs of fishes taken in 0-10 ^{o}/oo salinity water than in higher salinities (Fig. 17). Other notable relations to salinity were that shrimp, isopods, ostracods, fish, and live plants (diatoms) in stomachs increased and larval gastropods decreased as salinities increased. Tunicates, crabs, larval gastropods, and insects were only found in substantial numbers in fish collected at salinities < 20 ^{o}/oo, whereas ostracods were only found in stomachs of fish taken at salinities > 20 ^{o}/oo.

Because anchovy were the most numerous fish taken in the trawl samples, their stomach contents were processed separately to determine if one species was feeding differently in the three strata. Anchoa mitchilli consumed primarily zooplankton (ca. 50% of the recognizable prey), and also amphipods, detritus, echinoderm larvae, and diatoms at levels of > 3% by weight of the total sample. Zooplankton consumed for both years combined were about equal in all three strata, but were 83% by weight of stomach contents in fish from Faka Union Bay in 1983, perhaps because of increased zooplankton in May--40% of all stomach contents of all species in May were zooplankton, the highest for any month. Although fish did not contribute significantly to bay anchovy diets, fish were present in stomachs of anchovy collected from Strata I and III, due probably to the larger bay anchovy that
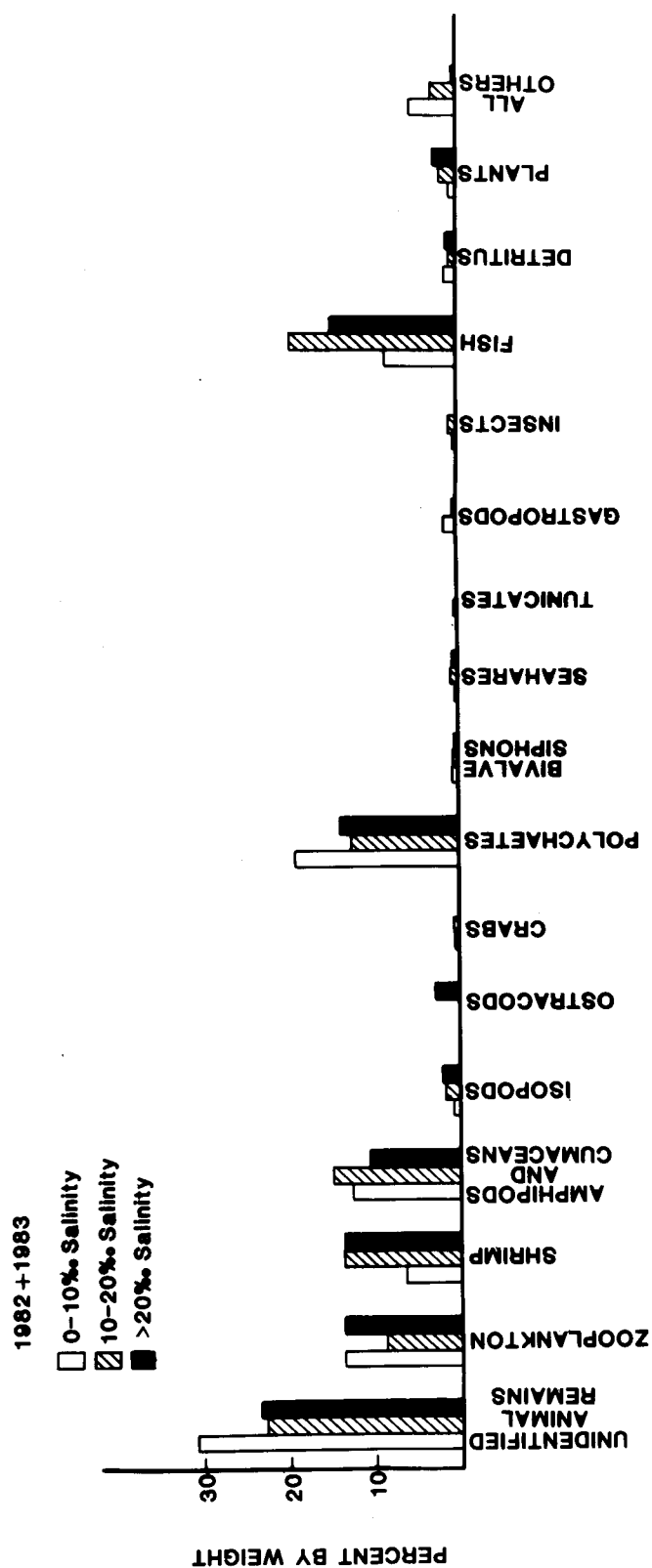
Figure 17. Comparison of low (0-10 ^{o}/oo), intermediate (10-20 ^{o}/oo), and high salinity (>20 ^{o}/oo) fish community stomach contents for all fish species and all monthly collecting periods (except February 1983).

we captured in September 1982 (Fig. 18). Diatoms were most abundant in samples from Stratum II (eastern stations), and amphipods and detritus were most abundant from Stratum III (western stations). Polychaetes, abundant in the overall stomach contents, were absent in bay anchovy stomachs.

Zooplankton were again consumed nearly equally by bay anchovy in all three salinity ranges in which we analyzed the data, as were amphipods (Fig. 19). Ostracods were most abundant in fish stomachs at salinities > 20 ^{o}/oo, echinoderms were not consumed by fish collected in salinities < 10 ^{o}/oo, and detritus was missing in high salinity samples.

A comparison between the diets of the most numerous species (A. mitchilli) and the second most numerous species (A. hepsetus, striped anchovy) shows that their diets were quite distinct (Table 17). Recognizable zooplankton contributed less than 30% by weight to the diets of striped anchovy, compared to about 50% by weight to the diets of bay anchovy. In Stratum I and Stratum III, the larger species (striped anchovy) preyed primarily on fish, but fish were missing in specimens from Stratum II. Shrimp were abundant in striped anchovy from Faka Union Bay, but nowhere else.

A comparison was made of the percent fullness of the stomachs of all fish species from the three strata. This index, calculated by dividing the total dry weight of all prey consumed by the total wet weight of the fish samples from which the stomach contents were extracted, was used to determine if Stratum I produced fish that were significantly different in their feeding success. A Chi-square test of the index showed that Faka Union Bay fish were not significantly different (0.51 vs 0.58) than the combined index (Table 18) for the eastern and western collateral bays (Strata II and III).
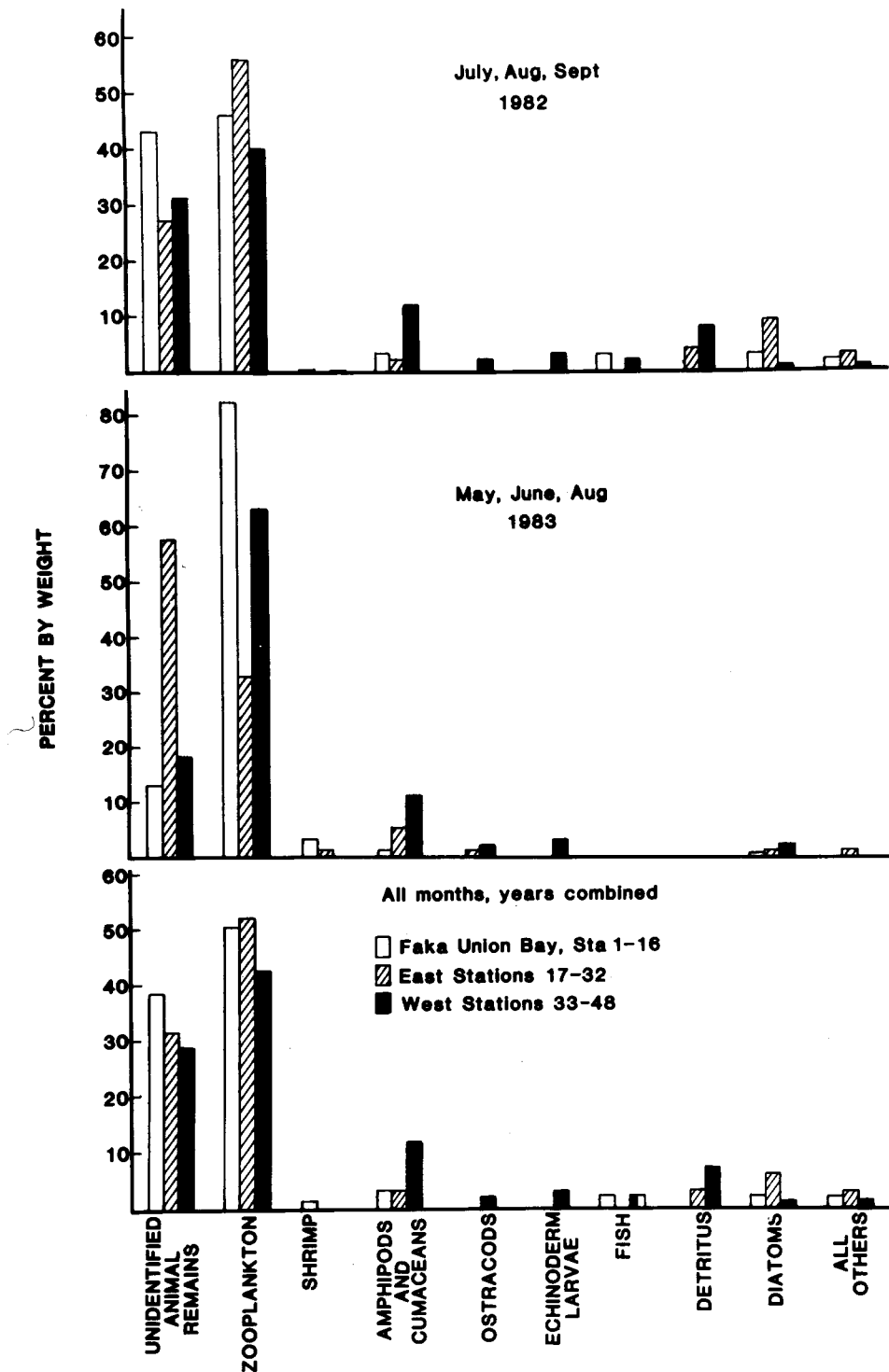
Figure 18. Comparison of Strata I, II, and III <u>Anchoa mitchilli</u> stomach contents by hear (top two panels) and average for combined years (bottom panel).
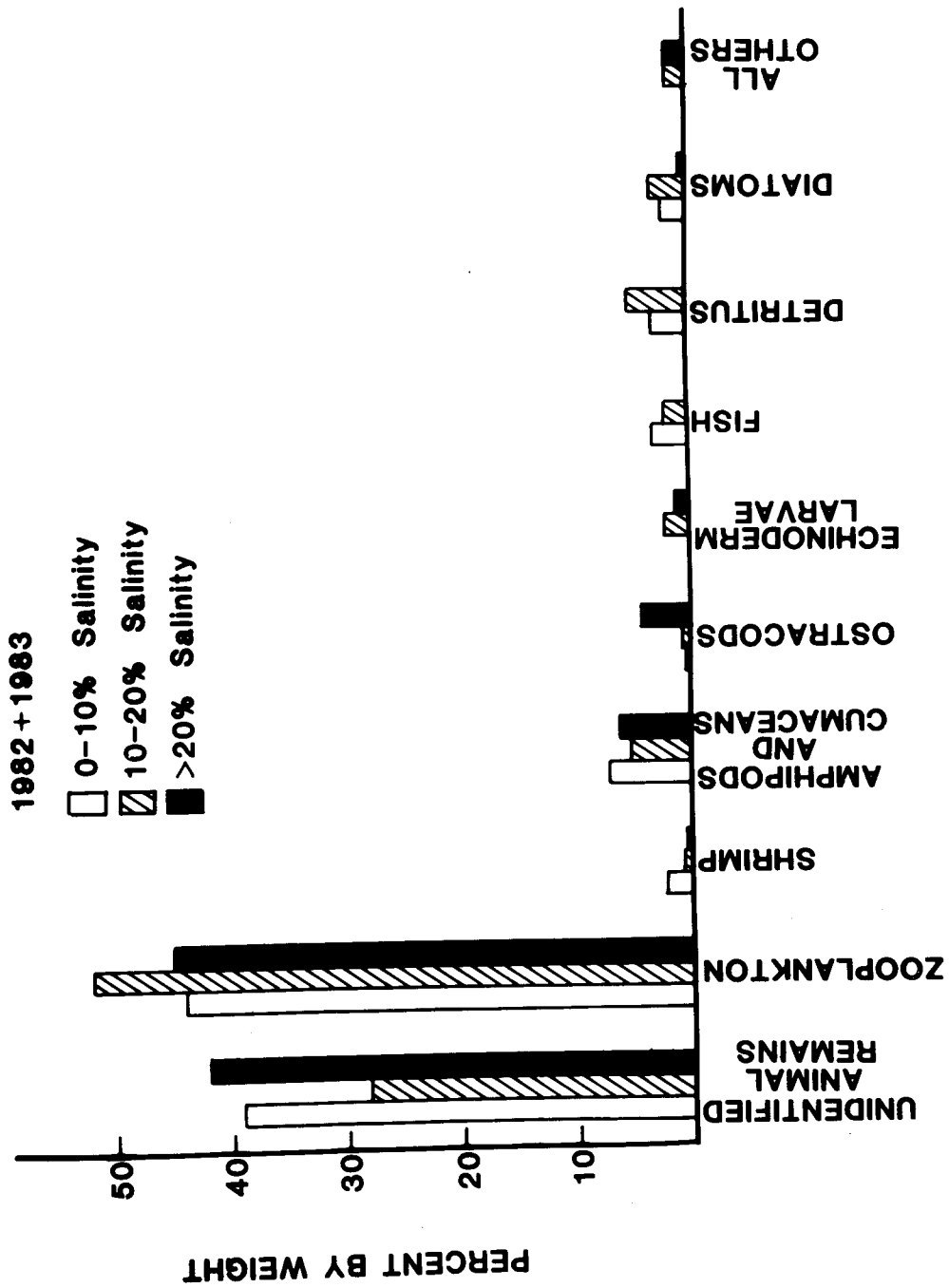
Figure 19. Comparison of low, intermediate, and high salinity *Anchoa mitchilli* stomach contents for all monthly collecting periods (except Feburary 1983).

Table 17. Percent by weight of the most abundant prey items in order of occurrence of the bay anchovy (A. mitchilli) and the striped anchovy (A. hepsetus) for both 1982 and 1983 collections from all strata.

	A. mitchilli		A. hepsetus	
	prey	%	prey	%
Stratum I	zooplankton	51	fish	39
	unrecognizable	39	zooplankton	22
	amphipods	2	shrimp	17
	diatoms	2	unrecognizable	13
	plant	2	cumacean	3
	cumacean	1	amphipods	2
	shrimp	1	detritus	1
Stratum II	zooplankton	53	zooplankton	39
	unrecognizable	32	amphipods	23
	diatoms	6	unrecognizable	22
	amphipods	3	plant	7
	detritus	3	astracods	5
	tunicates	2	crabs	1
			polychaetes	1
Stratum III	zooplankton	43	fish	38
	unrecognizable	29	unrecognizable	29
	amphipods	12	zooplankton	19
	detritus	7	amphipods	9
	echinoderm larvae	3	ostracods	2
	astracods	2	diatoms	2
	fish	2	invertebrate eggs	1
	diatoms	1		

Table 18. Percent fullness of all fish species stomachs from the three strata. The index is calculated by dividing the dry weight (mg) of food by the wet weight (g) of the fish subsample.

	Stratum I	Stratum II	Stratum III
Food dry wt (mg)	2268	2005	2928
Fish wet wt (g)	4484	3794	4567
Index	0.51	0.53	0.64

Invertebrates: A total of 8,142 non-molluscan macroinvertebrates representing 29 taxa were collected by surface and otter trawls during the six survey periods in which invertebrates were enumerated (Table 19). Representative species from the July 1982 survey were retained for identification purposes and to establish a reference collection but were not counted. In addition, 4,105 amphipods and 1,374 isopods were counted (Table 19), but because of the mesh size of the sampling gear they are not considered at all indicative of respective abundances in the areas sampled. The major amphipod and isopod taxa collected are listed in Table 20.

Three genera represented more than 80% of the macroinvertebrates we collected. Many of the species collected in surface and otter trawls by Carter et al. (1973) from the Faka Union and Fakahatchee Bays were either missing from our collections or present at low abundances. Pink shrimp (Penaeus duorarum), the xanthid mud crab (Neopanope texana texana), and the grass shrimps (Palaemonetes intermedius and P. vulgaris), dominated our collections, representing, on the average, 41%, 24%, and 19% of the invertebrates collected, respectively. Relative abundances of total invertebrates and of these three taxa were greater during the 1983 wet season than during the August and September 1982 wet season surveys (Fig. 20); this may be a function of the generally low salinities experienced by the entire area during 1982 (Fig. 3). Carter et al. (1973) also noted Penaeus and Palaemonetes to be dominant genera and that Neopanope was characteristically abundant. However, they reported the hippolytid shrimps (Hippolyte pleuracantha and Tozeuma carolinense) to be important (exceeding Neopanope in abundance), particularly in Fakahatchee Bay. These two genera are common seagrass bed inhabitants, and their general absence from our collections (Table 19) may

Table 19. Relative abundance of invertebrates collected in three strata in the vicinity of Faka Union Bay (Faka Union Bay, stations 1-16; Bays to the east, Stations 17-32; Bays to the west, Stations 33-48).

Species Taxon	August 1982			September 1982			February 1983			May 1983			June 1983			August 1983		
	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48
Panaeus duorarum	76	152	70	97	80	68	70	34	89	69	161	548	191	565	306	141	207	409
Palaemonetes intermedius	1	15	2	1	23	0	8	5	32	53	153	95	66	487	114	33	69	3
Palaemonetes vulgaris	1	7	0	0	7	0	67	103	82	1	46	17	0	58	5	0	2	1
Alpheus heterochaelis	0	1	2	1	1	1	1	12	40	0	0	2	3	11	3	1	3	13
Neopanope t. texana	12	188	53	4	56	6	13	27	34	32	209	753	50	357	94	15	54	25
Petrolisthes galathinus	1	3	3	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
Callinectes sapidus	4	5	1	8	3	3	50	54	82	17	56	24	14	39	16	8	8	13
Callinectes ornatus	0	0	0	0	0	0	13	3	15	1	4	2	1	6	2	0	0	0
Panopeus herbstii	3	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1
Rithropanopeus harrisii	1	22	6	4	6	0	0	13	24	2	5	16	33	54	1	12	16	20
Uca pugilator	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 19. Contd.

Species Taxon	August 1982			September 1982			February 1983			May 1983			June 1983			August 1983		
	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48
Libinia emarginata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Libinia dubia	0	1	0	0	7	0	1	6	4	3	3	6	1	2	2	0	0	0
Portunus sayi	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Periclimenes americanus	0	0	0	0	0	0	35	97	93	0	0	0	1	0	0	0	0	0
Periclimenes longicaudatus	0	0	0	0	0	0	0	12	23	0	0	0	0	0	0	0	0	0
Acetes americanus carolinae	0	0	0	0	0	0	2	5	3	0	0	0	0	0	0	0	1	0
Leptochela serratorbita	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
Tozeuma carolinense	0	0	0	0	0	0	0	2	0	0	2	0	0	3	0	0	0	0
Hippolyte zostericola	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0
Pinnotheres maculatus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Latreutes parvulus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Table 19. Contd.

Species Taxon	August 1982			September 1982			February 1983			May 1983			June 1983			August 1983		
	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48	1-16	17-32	33-48
Cancer borealis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Menippe mercenaria	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Loligo brevis	0	0	0	0	11	3	0	0	1	18	21	48	2	14	13	0	0	0
Limulus polyphemus	0	0	1	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Metoporhapis calcarata	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Ophioderma (sp)	0	0	0	0	0	0	0	1	3	0	0	6	0	0	2	1	0	3
Asterias forbesi	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Total Individuals	99	396	142	116	194	84	267	377	526	197	662	1521	341	1601	560	211	360	488
Total Species	8	11	11	7	9	6	12	14	15	10	12	15	9	16	13	7	8	9
Amphipods	0	0	2	0	0	18	1308	330	770	636	358	58	139	92	85	88	53	168
Isopods	0	1	1	1	0	0	67	213	179	195	604	27	41	15	22	8	3	0

Table 20. Taxonomic listing of amphipods and isopods collected from the
study area.

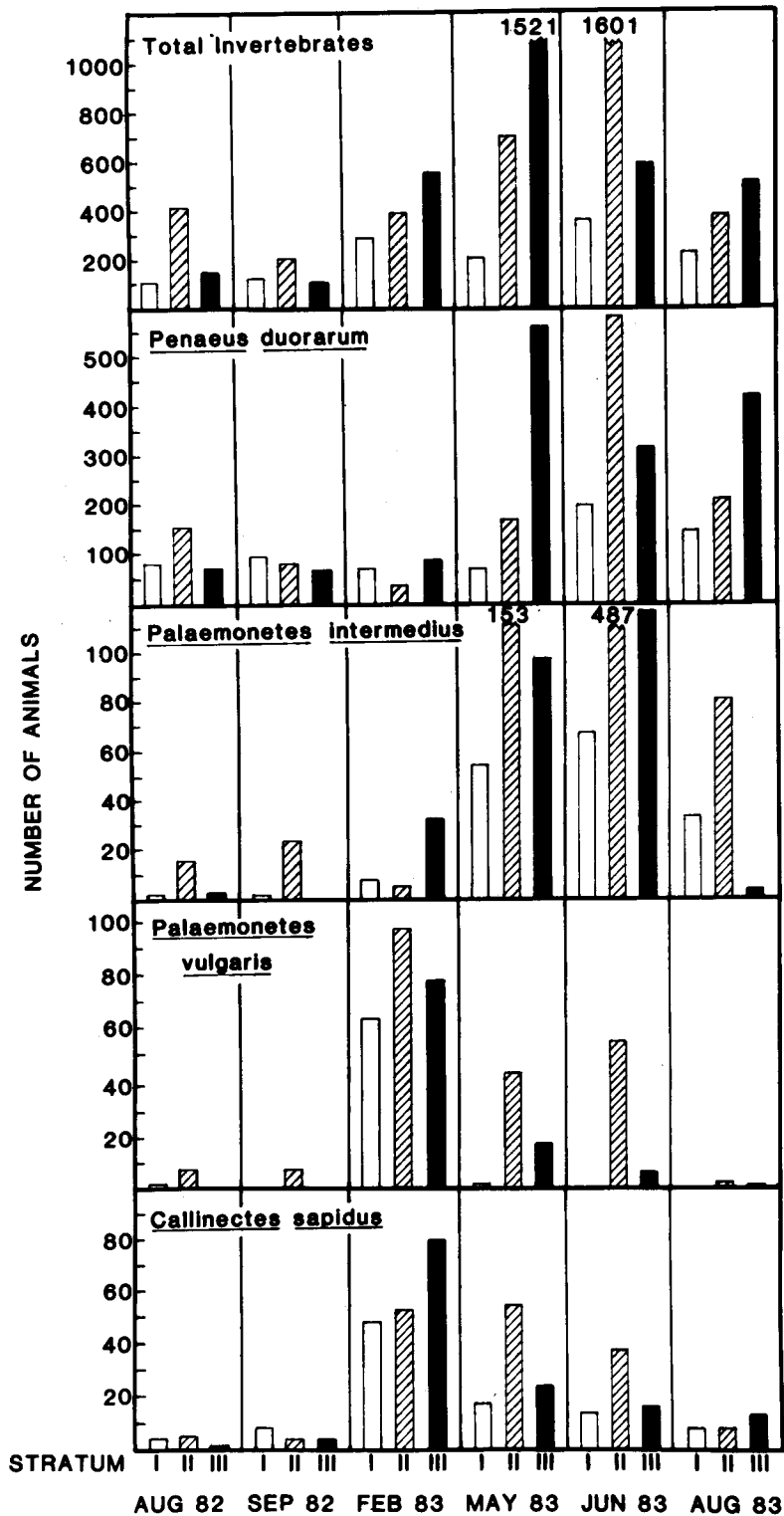| Amphipods	Isopods
Gammarus mucronatus	Aega psora
Ampithoidae	Cymothoa excisa
Cymadusa compta	Aega (sp)
Ampelisca (sp)	Erichsonella (sp)
Corophium (sp)	Cymodoce faxori
Orchestia (sp)	Cyathura (sp)
Elasmopus levis	

Figure 20. Relative abundance of total
macroinvertebrates collected within each
Stratum I, II, and III), and relative
abundance of major species during each
of the surveys in which invertebrates
were enumerated.

result from differences in seagrass bed densities between the two periods of study. Carter et al. (1973) reported fairly extensive seagrass beds in Fakahatchee Bay while our direct observations and qualitative by-catch of vegetative material (Table 11) suggest that seagrass beds are not as extensive as they were in the 1970's.

Differences in relative abundance of macroinvertebrates occurred among the three sample strata. Of the total number of individuals collected (excluding amphipods and isopods), 15% (1,231 individuals) were collected in Faka Union Bay (Stratum I, stations 1-16), 44% (3,597) in bays to the east (Stratum II, stations 17-32), and 41% (3,321) in bays to the west of Faka Union (Stratum III, stations 33-48). Approximately two-fold more pink shrimp were collected in bays to either the east (1,199) or west (1,490) than were collected in Faka Union Bay (644) with the same level of effort. An average of seven-fold more xanthid crabs were collected in either the east or west bays (928) than were collected in Faka Union (126). The area from Fakahatchee to Chokoloskee Bay (Stratum II, stations 17-32) provided about four-fold more grass shrimp (975) than were collected from either Faka Union (231) or the western bay stratum (351). These three genera often are major items in the diet of sport and commercial fishes, including snook (Marshall 1958; Carter et al. 1973), spotted seatrout, gray snapper (Croker 1962), red drum, lady fish, and silver perch (Carter et al. 1973).

Acknowledgments

LITERATURE CITED

American Society for Testing and Materials (A.S.T.M.) (1963). Standard
    method of particle size analysis of soils. A.S.T.M. designation
    D422-63, p. 205-217.

Bousfield, E.L. 1973. Shallow-water gammaridean amphipods of New England.
    Comstock Publishing Assoc. 312 p.

Bynum, K.H. and R.S. Fox. 1977. New and noteworthy amphipod crustaceans
    from North Carolina, U.S.A. Chesapeake Sci. 18: 1-33.

Carter, M.R., L.A. Burns, T.R. Cavinder, K.R. Dugger, P.L. Fore, D.B. Hicks,
    H.L. Revells, and T.W. Schmidt. 1973. Ecosystems analysis of the Big
    Cypress Swamp and estuaries. U.S. EPA, Atlanta, Georgia.

Collins, L.A. and J.H. Finucane. 1984. Ichthyoplankton survey of the
    estuarine and inshore waters of the Florida Everglades, May 1971 to
    February 1972. NMFS Tech. Rep. NMFS.

Croker, R.A. 1962. Growth and food of the gray snapper, Lutjanus griseus,
    in Everglades National Park. Trans. Amer. Fish. Soc. 91: 379-383.

Cross, R., and D. Williams, eds. 1981. Proceedings of the National Symposium
    on Freshwater Inflow to Estuaries. U.S. Fish and Wildlife Service,
    Office of Biological Services. FWS/OBS-81/04. 2 Vol.

Davis, J.H., Jr. 1946. The peat deposits of Florida, their occurrence,
    development, and uses. Fla. Geol. Surv. Geol. Bull. 30:1-247.

Department of the Army, Jacksonville District, Corps of Engineers. 1980.
    Reconnaissance report: Golden Gate Estates, Jacksonville, Fl.

Felder, D.L. 1973. An annotated key to crabs and lobsters (Decapods
    Reptantia) from coastal waters of the Northwestern Gulf of Mexico.
    LSU-SG-73-02. 101 p.

Gosner, K.L. 1971. Guide to identification of marine and estuarine invertebrates. John Wiley and Sons, Inc. 693 p.

Lindall, W.N., Jr., J.R. Hall, W.A. Fable, Jr., and L.A. Collins. 1974. Fishes and commercial invertebrates of the nearshore and estuarine zone between Cape Romano and Cape Sable, Florida. NTIS PB 235-315.

Marshall, A.R. 1958. A survey of the snook fishery of Florida, with studies of the biology of the principal species, Centropomus undecimalis (Bloch). Fla. St. Bd. Conserv., Tech. Ser. No. 22-